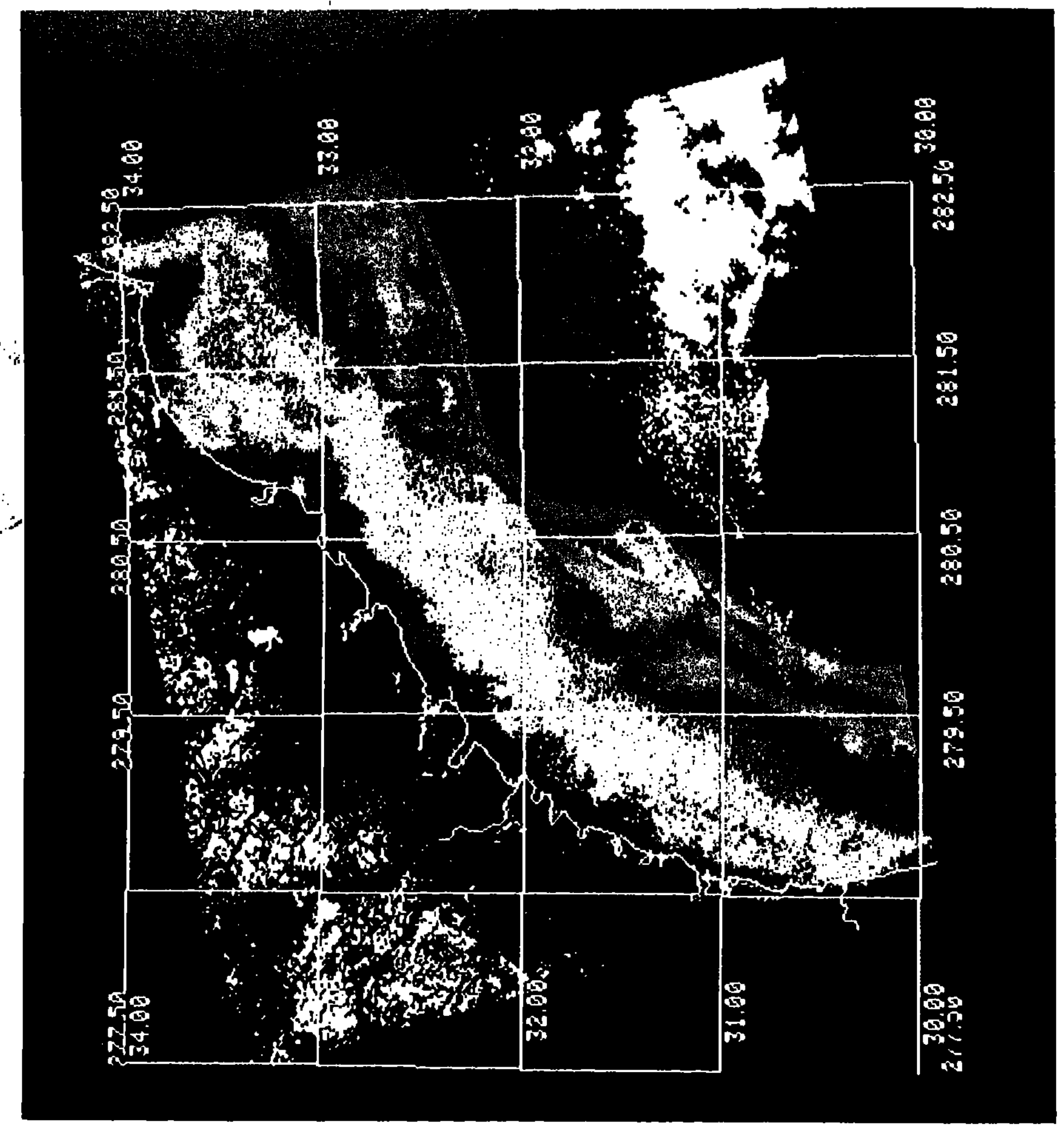

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Vol. 65 No. 49 December 4, 1984

The Oceanography Report, page 1202

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Oceanography

4713 Circulation

NEAR EQUATORIAL CTD OBSERVATIONS AT 95°W IN OCTOBER 1982

J. M. Toole (Woods Hole Oceanographic Institution, Woods Hole MA 02543)

CTD data collected about the equator along 95°W between 8 and 12 October 1982 are used to investigate stratification changes in the upper 1 km associated with the 1982/83 El Niño. With respect to the thermal field observed in November 1981, virtually the entire section exhibited downward displacements in the upper kilometer of the water column. Observed displacements at the depth of the mean thermocline were large, ~ 150 m, and relatively symmetric about the equator. Displacements around 1 km depth were near zero. This stratification change appears to have been produced by a zonal convergence of mass at temperatures above 15°C with divergence below. Least square model decompositions of the vertical displaced profiles revealed significant contributions from modes 1 and 2 with meridional structure consistent with Kelvin waves. The observations thus support current theories that relate El Niño onset in the eastern Pacific to anomalous wind forcing in the west. (El Niño, Kelvin waves).

J. Geophys. Res., C, Paper 4C1221.

4713 Circulation (Mediterranean Sea)

SOME FEATURES OF THE ALGERIAN CURRENT

Claude MILLOT (Antenne Muséum, PB 132, 83501 La Seyne-F)

An analysis of infrared images leads to a new conception of the dynamics of the Atlantic Water in the Algerian Basin. In situ current measurements are not yet available but coherent hypotheses are presented with the aim to initiate further experimental and theoretical works.

The Algerian Current flows steadily along the coast near 0° and becomes unstable near 1-2°E. Eddies of both signs are generated that are advected by the mean current, but only the anticyclonic eddies increase in size (diameter of about 100km). As they extract more energy from the mean current, they are advected more slowly, they may detach from the coast and drift for several weeks in the Algerian Basin. They grow as deep as a thousand meters at least and they are able to pull lenses of Intermediate Water seaward from the Sardinian continental slope.

Coastal upwelling cells are generated near 1-2°E between the cyclonic and the anticyclonic eddies; they are also advected by the mean current and are definitively not wind-induced. These turbulent structures create fronts mixing between the Atlantic and Mediterranean waters, which account for the large eastward gradient of salinity encountered in the surface layer.

Therefore, the Algerian Basin is characterized by a large mesoscale variability mainly due to the instability of the Algerian Current. It appears to be a reservoir in which the water of Atlantic origin is ... and it forms a buffer zone which disconnects the flow of Atlantic Water coming in at Gibraltar from the flow of highly modified Atlantic Water exiting the basin through the Strait of Sardinia and into the Tyrrhenian Sea. (Western Mediterranean Sea, meso-scale turbulence, upwellings).

J. Geophys. Res., C, Paper 4C1265

4713 Circulation

STRUCTURE AND SEASONAL CHARACTERISTICS OF THE GASPE CURRENT

J. Benoit (Mobil Oil Canada Ltd, P.O. Box 62, St-John's, Newfoundland, Canada A1C 6C9), M.I. El-Sabh and C.L. Tang

CTD and current meter data from the northwestern Gulf of St.Lawrence were analyzed to study the structure and variability of the Gaspé Current. Since the current is buoyancy-driven, its properties are strongly influenced by the seasonal variation of the freshwater discharge from the St.Lawrence Estuary. From June to November, maximum speed decreases from 110 cm s^{-1} to 60 cm s^{-1}. High vertical shears exist in the upper 40 m of the water column. During the same period, the width of the current decreases and the position of the current maximum shifts from near the shore to about 14 km from the shore. These changes in the structure can be understood in terms of geostrophy and baroclinic deformation radius. In the temperature/salinity field, the most prominent change from June to November is the continuing increase of surface salinity. Temperature change occurs mainly in the September-November period, when atmospheric cooling accelerates. The effect of atmospheric cooling is also reflected in the density distribution, with the result that in November currents in the upper 30 m are weakest in the entire section (from Sept-Iles to Marche de Gaspé), while in the summer months, the currents are strongest in the southern part and westward in the northern part of the section. Momentum balance of the current system is also investigated. It was found that east of Pointe-des-Monts, geostrophic balance is maintained while west of Pointe-des-Monts the observations do not seem to be consistent with the assumption of geostrophy. (St.Lawrence, mixing, variability, currents).

J. Geophys. Res., C, Paper 4C1377.

4799 General (Sea Ice Modeling)

SENSITIVITY OF A THERMODYNAMIC SEA ICE MODEL WITH LEADS TO TIME STEP SIZE

Tamara Shapiro Ledley (Department of Space Physics and Astronomy, Rice University, Houston, TX, 77251)

A thermodynamic sea ice model which is numerically structured to take time steps on the order of a week is found to be sensitive to time step size when new ice formed on open ocean is assumed to cover the ice free area. This sensitivity is caused by the extrapolation of initial ice growth rates on open ocean, which can be very high, over the length of the time step. The sensitivity to time step size is tremendously reduced when the parameterization for the formation of new ice is altered so that the new ice thickness is specified. However, the sensitivity continues during the winter when the area of open ocean is small because the volume of ice formed over the time step is more than enough to fill the open area at the specified thickness. Therefore, ice thickness during the winter is again determined by time step size. Suggestions are made on how the sea ice model's sensitivity to time step size can be further reduced without sacrificing computational efficiency. (Sea ice models, time step size).

J. Geophys. Res., D, Paper 4D1311

Particles and Fields—Magnetosphere

5720 Interaction Between Solar Wind and Magnetosphere

POLAR CUSP DYNAMICS

Robert H. Eather (Physics Department, Boston College, Chestnut Hill, Mass., 02167)

The position of dayside aurora (as measured from South Pole station in 1981) is compared to the interplanetary magnetic field B_z component and to the AE index. The results are consistent with our earlier work showing a close relationship with AE and little correlation with B_z. Two recent papers have presented data that were interpreted as indicating a dominant B_z correlation. A reconsideration of the data sets used in these papers does not support dominant B_z dependence, and in fact reaffirms a close dependence on AE. We conclude that the position of the dayside cusp is largely controlled by substorm processes internal to the magnetosphere rather than by direct merging and erosion processes with the interplanetary field. (Polar cusp, auroras).

J. Geophys. Res., A, Paper 4A0229

AGU Congressional Science Fellowship

The individual selected will spend a year (September to August) on the staff of a congressional committee or a House or Senate member, advising on a wide range of scientific issues as they pertain to public policy questions.

Prospective applicants should have a broad background in science and be articulate, literate, flexible, and able to work well with people from diverse professional backgrounds. Prior experience in public policy is not necessary, although such experience and/or a demonstrable interest in applying science to the solution of public problems is desirable.

The fellowship carries with it a stipend of up to $28,000, plus travel allowance.

Interested candidates should submit a letter of intent, a curriculum vitae, and three letters of recommendation to AGU. For further details, write Member Programs Division, American Geophysical Union, 2000 Florida Avenue, N.W., Washington, D.C. 20009 or telephone 462-6903 or 800-424-2488 outside the Washington, D.C., area.

Deadline: April 1, 1985

The Eastern Maritime Boundary Between the United States and Canada

David A. Brooks
Department of Oceanography, Texas A&M University, College Station, Texas

Introduction

The easternmost part of the United States is separated from Canada by an imaginary line in the ocean. The oceanic boundary is evidence of the extensive marine heritage of the state of Maine and the Canadian province of New Brunswick. The International Court of Justice at The Hague (the "World Court") recently handed down a decision which extended the boundary line across the Gulf of Maine and Georges Bank. The action was intended to resolve a long-standing controversy over fishing rights on Georges Bank (*Eos, 65,* (45), p. 801, 1984). The extension of the line adds a modern chapter to a maritime boundary dispute which is older than the government of either nation. The controversy is rooted in imprecise language used in the Treaty of Paris, which officially separated the nascent United States from Great Britain in 1783. Faced with sorting out the implications of the recent boundary decision, it is well to recall and perhaps benefit from the long history of related events, most of which had serious economic and personal consequences for residents on each side of the border.

Past

In the summer of 1604, Sieur de Monts and his pilot, Samuel de Champlain, passed through the islands of a North American bay and ascended a river which they found on its western side (Figure 1). On an island in the river estuary, they founded the first non-native settlement on these shores. The island was named Isle de la Croix because river branches above the island formed the shape of a cross. The indians called the bay Passamaquoddy, which referred to great quantities of pollock taken there; and they called the river Schoodic, which meant a "great clear place" burned by forest fires [*Kilby*, 1884].

The settlers suffered a disastrous winter. In the spring, the survivors abandoned the island and eventually moved to Port Royal (now Annapolis Royal), Nova Scotia, where a French colony was already established. Although the settlement failed, it set a precedent which ultimately determined that the international boundary would lie in the Schoodic River, which later became known as the St. Croix River (Figure 1). This seems straightforward today, but the matter was confused at the time of the American Revolution, because a different Passamaquoddy river (the Magaguadavic) was then known as the St. Croix.

The Treaty of Paris specified that the eastern boundary was to be given by a line "...along the middle of St. Mary's River [in mid-Florida] to the Atlantic Ocean, [then] east to a line to be drawn along the middle of the River St. Croix from its mouth in the Bay of Fundy to its source..." To apply the terms of the treaty, it was first necessary to resolve the confusion over which was the "true" St. Croix River and then to decide where its mouth was located. A boundary commission was appointed in 1794, but the matter remained unsettled until 1798, 10 years after the United States Constitution was ratified. In the meantime, Loyalist refugees founded the town of St. Andrews between the two rivers, in the contested region.

The British commissioners initially argued that the St. Croix River mouth was located in the upper Schoodic estuary. From there they extended the boundary line directly toward Florida, following the treaty instructions literally (solid line, Figure 1). The line left in British possession part of the mainland and all of the Passamaquoddy Islands. At the time, Moose Island supported a population of about 20 families, who considered themselves citizens of the United States.

The United States commissioners initially took the equally untenable position that the Magaguadavic River was the true St. Croix. Their argument was based on local testimony and an inaccurate map dating from about 1760 (the same map used in drafting the Treaty of Paris). The boundary line claimed by the United States, also shown on Figure 1 (dashed line), retained Moose and Grand Manan Islands, but it excluded Campobello Island, where British precedent was clearly established.

After 4 years of deliberation, the commission finally decided that the Schoodic was the river in question and that its mouth was properly located at the estuary constriction near St. Andrews. The Schoodic was chosen partly because alewives, herring, and bass were known to be exceedingly abundant there; this agreed with similar observations recorded by Sieur de Monts 185 years earlier. The river mouth was located near St. Andrews because whales and grampuses were found farther south; in the commissioners' view, this made the lower Schoodic estuary part of the bay and not the river. Key testimony was given by Captain Timothy Folger of Nantucket, who had taken a whale in the estuary. The same Folger provided whalers' information which Benjamin Franklin used in his 1769 chart of the Gulf Stream. Having discharged its assigned duties, the commission disbanded in 1798 without extending the boundary line from the newly determined river mouth to the Bay of Fundy, thus leaving the islands' nationality unresolved. The town of Eastport was incorporated on Moose Island in the same year.

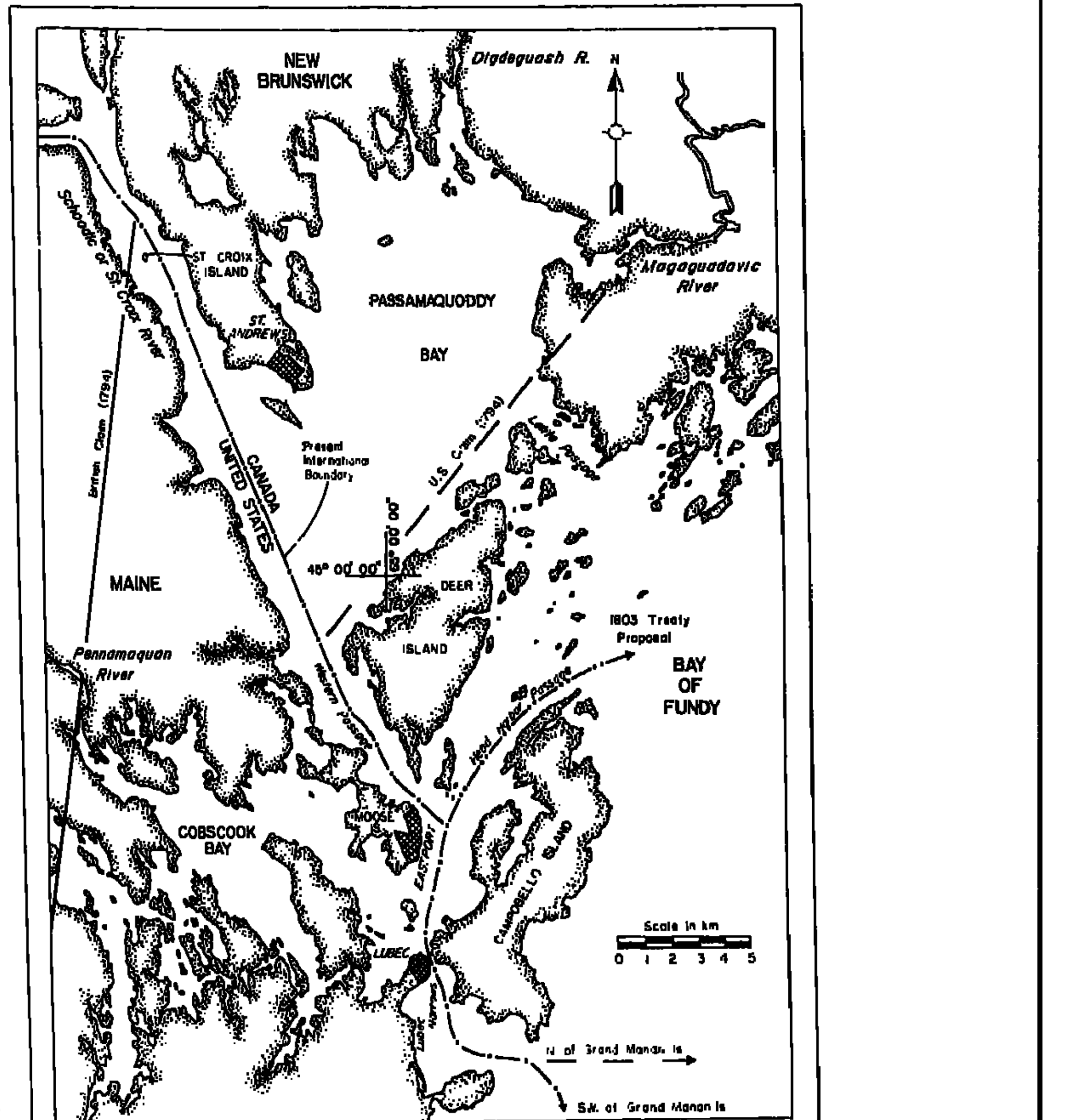


Fig. 1. Map of the Passamaquoddy Bay region, showing the present international boundary. Also shown are approximations to the lines initially claimed by the British and United States sides when the Boundary Commission convened in 1794 to implement the terms of the Treaty of Paris [*Kilby*, 1884]. The line dividing Head Harbour Passage, which is the principal channel connecting Passamaquoddy Bay with the Bay of Fundy, was proposed in an 1803 treaty which was not ratified. De Monts' 1604 settlement was on St. Croix Island (Isle de la Croix) in the river then known as the Schoodic but now named the St. Croix.

The early nineteenth century was typified by growing tensions in the Passamaquoddy region. Jurisdictory claims over Moose Island were pressed with increasing fervor by the British side, while Eastport grew in size and prosperity. During this time, two treaties were negotiated which would have resolved the issue, but neither was ratified by the United States because of difficulties over wording in unrelated articles. The 1803 treaty attempt is especially significant, because it proposed that the line should descend the Western Passage, as it presently does, but then turn northeastward between Deer and Campobello Islands (dashed double-dotted line, Figure 1), thereby providing equal access to the primary channel between Passamaquoddy Bay and the Bay of Fundy. Campobello was uncontested, as before. This equitable proposition failed, and consequently vessels bound into or out of United States ports in Passamaquoddy Bay must pass through Canadian waters. The Lubec Narrows, through which the present boundary line passes, is a hazardous channel with very strong tidal currents and a low bridge.

Soon after the Embargo Act of 1807, a military fort was built and garrisoned on Moose Island. Guns were mounted and trained on the harbor. As the embargo tightened, smuggling became openly prominent, attracting adventurers from great distances on both sides of the border. Under cover of darkness and fog, small-boat traffic was lively, and an international trade in contraband flourished for several years [*Brown*, 1968]. This was certainly the most colorful, if not the most admirable, period in Moose Island history.

War was finally declared in June of 1812. In July 1814, just 5 months before the Treaty of Ghent ended the hostilities, a British military fleet of at least 10 vessels, including a 74-gun ship-of-the-line, sailed up Head Harbor Passage on the flooding tide. The fleet was commanded by Admiral Thomas Hardy, who landed at Eastport under a flag of truce and demanded immediate surrender of the fort and town. The fort's commander was convinced to take this prudent action, which certainly saved the town from destruction by the vastly superior British force. Without a shot being fired, troops occupied the town, and the Union Jack flew over the island until 1818.

Moose Island was a major point of contention in the negotiations leading to the Treaty of Ghent. To achieve the peace, it was necessary to refer the island issue to a new commission for resolution. The commission met for the first time late in 1816 and rendered its decision about a year later. In the end, the British side agreed to relinquish its claim to Moose Island in return for uncontested sovereignty over Grand Manan Island. Finally, in June of 1818, the troops left Moose Island, and for the first time its residents took clear title to United States citizenship. The boundary line was officially extended through the Lubec Narrows into Grand Manan Channel (Figure 1, dashed-dotted line).

Prologue

On October 12, 1984, the World Court reached a compromise decision which extended the boundary line across the Gulf of Maine and the eastern third of Georges Bank (Figure 2). Both countries agreed in advance to accept the court's decision. Previously, the United States had claimed a "Fishery Conservation Zone," bounded by a line that extended from the center of Grand Manan Channel across the deepest part of Jordan Basin and then out the center of Northeast Channel (dashed line, Figure 2). The new line provides Canadian access to the rich Georges Bank fishing grounds known as Northeast Peak, which had previously been claimed entirely by the United States. The decision leaves each country with roughly equal areas of shoal fishing banks on the outer continental shelf. The new line also provides additional United States access to the deep waters of Jordan Basin.

Surface currents generally move in a counterclockwise direction inside the Gulf of Maine and in a clockwise direction around Georges and Browns Bank [*Bigelow*, 1927; *Bumpus and Lauzier*, 1965; *Bulman et al.*, 1982; *Smith*, 1983]. In the spring and summer, waters from Wilkinson Basin move eastward in a narrow current which flows along the inner edge of Georges Bank. The current follows the depth contours around the Northeast Peak and out the Northeast Channel (Figure 2). There is an inflow at most depths on the northeastern side of the Northeast Channel

Article (cont. on p. 1210)

Editorial

AGU GIFT: a Report

The GIFT Fund continues to grow, both in the dollar value and the number of participants. The fund is now close to $270,000, and now that the 1985 dues notices have been mailed, we expect the response to the "voluntary contribution" line to push the level well beyond $300,000 by the end of the year. Also, the number participating will probably exceed 7000. We thank all of you.

Since the time of our last report (to Council at the 1984 Spring Meeting), members of the Steering Committee have been writing personal letters, more than 500, to some of you who have not been participating in this appeal to the level that we would expect. In addition, letters went to some who may have overlooked their annual contribution or were waiting for a friendly reminder. The response to this special effort has been encouraging—but not overwhelming. Perhaps the mail has been a bit slow.

In addition to the letters addressed to the individual members, a special appeal was made to the AGU representatives of our institutional members, asking them to encourage their organizations to make major contributions to the fund. Similar appeals will be made to those corporations which are not AGU institutional members but have many AGU members among their employees. These are organizations which have strong continuing interests in geophysics and have benefited in a variety of ways from their associations with AGU and its members. We welcome your suggestions for other potential donors and, in particular, the identification of key persons within organizations which we could contact.

As we approach the final year of this campaign, we plan to renew our efforts to seek larger contributions (or pledges) from those of you who have prospered significantly from your careers and professions in geophysics. We are falling far short of the number that we had hoped would sense the opportunity that exists for accumulating sufficient funds to essentially eliminate the mortgage by 1986—the first date that the contract provides for making any prepayment. We had estimated that at least 100 members would subscribe to be Life Supporting Members, pledging $300 a year for 5 years or a total of $1500. The plaque at headquarters now shows 21 in this category. We believed there were 50 members who would contribute $1000 a year for 5 years and be recognized as Sustaining Members. To date the plaque bears three such names. We were hopeful that there might be five members who would contribute $2000 a year for a 5-year period and be recognized as Benefactors. There is ample space on the plaque but, at the moment, only one name.

Those who do make major contributions to worthy causes are well aware of the tax benefits which now exist but which may not exist in the future if there are changes in our U.S. tax laws. Plan ahead!

Earl G. Droessler
Charles A. Whitten
Cochairmen, Steering Committee

Article *(cont. from p. 1209)*

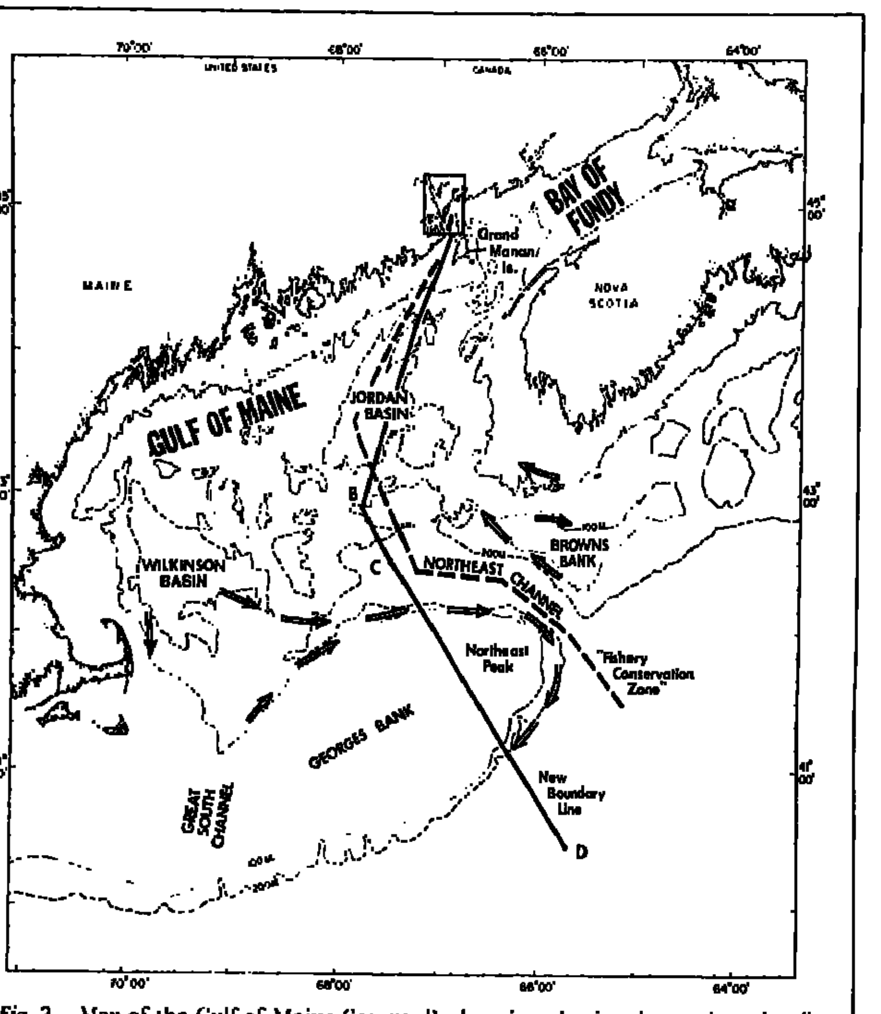


Fig. 2. Map of the Gulf of Maine-Georges Bank region, showing the new boundary line and the old "Fishery Conservation Zone" line. The new line is determined by the following coordinates (U.S. Coast Guard, *Notice to Mariners, 42*, October 16, 1984): (A) 44°11'12" N, 67°16'46" W; (B) 42°53'14" N, 67°44'35" W; (C) 42°31'08" N, 67°28'05" W; and (D) 40°27'05" N, 65°41'59" W. The arrows show elements of the surface circulation in the Gulf and around the banks. The inset box shows the region covered by the map in Figure 1.

(S. Ramp et al., unpublished manuscript, 1984). The deep water spreads northward and westward into the interior basins. Less is known about the winter currents, but as the season progresses, the jetlike flow along the inner edge of the bank weakens, and the water develops a seaward movement across the top of the bank.

The prominent Georges Bank fishery includes scallops, cod, halibut, haddock, and herring. The richness of the fishery is partly due to tidal stirring of the shoal bank waters, which brings nutrients to the surface [*Garrett et al.*, 1978; *Yentsch and Garfield*, 1981; *Brown*, 1984]. The current from the western gulf also carries nutrients, which can be injected onto the top of Georges Bank by upwelling, lateral mixing, or other physical processes [*Hopkins and Garfield*, 1981]. Primary production is most vigorous along the northern edge and on the Northeast Peak of Georges Bank, and the clockwise circulation around the bank seems to confine and enrich the fishery on the Northeast Peak [*Flagg et al.*, 1982].

Atlantic slope water enters the Gulf of Maine only through the Northeast Channel, which lies entirely on the Canadian side of the new boundary line. Slope water carries important amounts of heat and salt, and these strongly influence the interior oceanic climate of the Gulf. In the spring, slope water accumulates in an inner depression of the Northeast Channel, where middepth Atlantic fish species (e.g., tuna) may be more abundant.

The Northeast Channel is also the principal navigational channel connecting the Gulf of Maine with the Atlantic Ocean. Consequently, vessels bound to and from ports in the gulf will have to pass through Canadian waters or use the shallower Great South Channel. The additional complexity may only be an inconvenience for shipping, but it echoes the much earlier instance in which international access to ports in Passamaquoddy Bay was similarly lost.

Summary

The maritime boundary between the United States and Canada was recently extended across the Gulf of Maine and Georges Bank by a decision of the World Court. The decision gives the two countries roughly equal access to the shallow bank areas of the outer continental shelf between Cape Cod and Nova Scotia, but it does not allow for the fact that the prevailing ocean currents tend to concentrate the fishery toward the eastern end of Georges Bank. The decision furthermore places the deep Northeast Channel entirely within Canadian jurisdiction. As a result, vessels bound between Europe and ports in the Gulf of Maine must pass through Canadian waters or use the more distant and shallower Great South Channel.

References

Bigelow, H. B., Physical oceanography of the Gulf of Maine, *U.S. Fish. Bull., 40*, 511–1027, 1927.

Brown, C. D., Eastport: A maritime history, *Am. Neptune, 28*(2), 113–127, 1968.

Brown, W. S., A comparison of Georges Bank, Gulf of Maine and New England shelf tidal dynamics, *J. Phys. Oceanogr., 14*, 145–167, 1984.

Bumpus, D. F., and L. M. Lauzier, Surface circulation on the continental shelf of eastern North America between Newfoundland and Florida, in *Serial Atlas Mar. Environ.*, Folio 7, 4 pl, 8 pp., Am. Geogr. Soc., Milwaukee, Wisc., 1965.

Butman, B., R. C. Beardsley, B. Magnell, D. Frye, J. A. Vermersch, R. Schlitz, R. Limeburner, W. R. Wright, and M. A. Noble, Recent observations of the mean circulation on Georges Bank, *J. Phys. Oceanogr., 12*, 569–591, 1982.

Flagg, C. N., B. A. Magnell, D. Frye, J. J. Cura, S. E. McDowell, and R. I. Scarlett, Interpretation of the physical oceanography of Georges Bank, vol. 1, *E. G. & G. Environ. Consul. Rep. 82-B4569*, U.S. Dept. of Inter., Bur. of Land Manage., Washington, D. C., 1982.

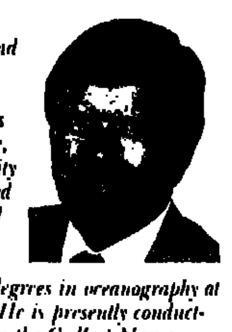
Garrett, C. J. R., J. R. Keeley, and D. A. Greenberg, Tidal mixing versus thermal stratification in the Bay of Fundy and the Gulf of Maine, *Atm. Ocean, 16*(4), 403–423, 1978.

Hopkins, T. S., and N. Garfield III, Physical origins of Georges Bank water, *J. Mar. Res., 39*, 465–500, 1981.

Kilby, W. H., *Eastport and Passamaquoddy*, Shead, Eastport, Maine, 502 pp., 1884. (Also available with a new forward, Border Historical Society, Eastport, Maine, 533 pp., 1982.)

Smith, P. C., The mean and seasonal circulation off southwest Nova Scotia, *J. Phys. Oceanogr., 13*, 1034–1054, 1983.

Yentsch, C. S., and N. Garfield III, Principal areas of vertical mixing in the waters of the Gulf of Maine, with reference to the total productivity of the area, in *Oceanography from Space*, edited by J. F. R. Gower, pp. 303–312, Plenum, New York, 1981.



David A. Brooks is a physical oceanographer and an associate professor of oceanography at Texas A&M University. He was raised in Eastport, Maine, and attended the University of Maine, where he earned a B.S. degree in electrical engineering. Succumbing to wanderlust, he then earned M.S. and Ph.D. degrees in oceanography at the University of Miami. He is presently conducting a research program on the Gulf of Maine, which shows the cyclic nature of history and makes for a long commute.

News

Acid Rain Stone Test Sites

As a part of the United States National Acid Precipitation Assessment Program, Task Group G: Effects on Materials and Cultural Resources, which is chaired by Ray Herrmann, the National Park Service has established four test sites for 10-year testing of two kinds of dimension stone used in buildings and monuments. The four sites are (from south to north) Research Triangle Park near Raleigh, N. C. (activated May 25, 1984); the roof of the West End Branch of the Washington, D. C., Library (activated August 11, 1984); the Department of Energy Compound at the Environmental Measurements Laboratory of Bell Telephone Laboratories near Chester, N. J. (activated June 5, 1984); and Huntington Wildlife Forest in the Adirondack Mountains, Newcomb, N. Y. (activated June 19, 1984).

Salem limestone from near Bedford, Ind., and the Royal variety of Shelburne marble from near Danby, Vt. were selected for testing. Although "granite" is the most commonly used dimension stone, detectable effects in the 10-year testing period are not assured. Caliper measurements on marble tombstones, etc. (N. S. Baer and S. M. Berman, "Marble tombstones in national cemeteries as indicators of stone damage," in *Proc. Annu. Meet. Air Pollut. Control Assoc., 83* (5.7), 1983) and disappearance of the polish from marble store fronts in less than 10 years (E. M. Winkler, "The measurement of weathering rates," in *Assoc. Preserv. Technol. Bull.*, in press) indicated that detectable effects should be observed in carbonate rocks. In addition, T. N. Skoulikidis ("Atmospheric corrosion of concrete reinforcements, limestones, and marbles," in *Atmospheric Corrosion*, edited by W. H. Ailor, pp. 807–824, John Wiley, N. Y., 1982) ascertained, from molds made in the 1920's of ancient marble statues plus subsequent photographs, that degradation of the Acropolis rapidly accelerated over the last 20–25 years, coincident with the industrialization of Greece and the use of high-sulfur fuels.

After granite, limestone is the second most widely used dimension stone. The Salem limestone has provided 53% of the total limestone dimension stone used in the United States in the period 1880–1980 (J. P. D'Agostino and R. J. Atelsek, "Present status of the dimension stone industry," USGS administrative report, Geol. Div., Reston, Va., 1984). Many well-known buildings are built, at least in part, of this stone. These buildings include the Empire State Building in New York City and the National Cathedral in Washington, D. C.

Georgia and Vermont have produced comparable dollar amounts of marble. The Shelburne marble of Vermont more often receives a polish, and the quarries are more centrally located in the area of greatest concern over acid rain. Therefore the Royal variety of Shelburne marble was chosen. The Royal variety contains silicate patterns mainly of chlorite and secondarily of phlogopite. The Jefferson Memorial and the new French Embassy in Washington, D. C., are examples of structures faced with Shelburne marble.

Samples exposed are mainly of two kinds: slabs that are 0.31 × 0.61 m and briquettes that are 7.31 × 8.25 cm. All samples are 5.08 cm thick. Briquettes are exposed in racks of polymethyl methacrylate and slabs in racks of polypropylene (for trace element purity). Installation of the sites was done by National Bureau of Standards (NBS) and the National Park Service. Current experiments on slabs involve analysis of the chemistry of runoff water by Michael Reddy of the U.S. Geological Survey (USGS) Water Resources Division in Denver, Colo. Experiments on briquettes include nondestructive visual and near-infrared measurements by Larry Rowan and Marguerite Kingston, destructive mineralogical and chemical profiling by Malcolm Ross, and documentary photography by Deborah Dwornik, all of the USGS Geologic Division in Reston, Va. American Society for Testing and Materials color change measurements are being made by Larry Knab, NBS, Gaithersburg, Md.

C. Arthur Youngdahl of the Argonne National Laboratory, Chicago, Ill., is leading a number of experiments. The first is monitoring surface chemistry change by using 0.3-mm-thick shavings from the surfaces of briquettes. A second is weight loss. Another is measurement of surface roughness and recession by holographic laser moire contouring being done by Cesar Scimmarella of Illinois Institute of Technology and Argonne National Laboratory (ANL). The last experiment, performed by William Primak of ANL, gauges surface recession occurring from individual precipitation events by using Twyman-Green interferometry, which utilizes mercury vapor light. Both of the surface recession methods measure the height of steps that develop between protected and unprotected areas of samples.

In early results on samples from Research Triangle Park, the pH of rain has been about 4.0–4.2, whereas the pH of runoff water is close to 8. There is little doubt of the rapid reaction of acid precipitation with the carbonate test stones. After a 3.81-cm rainfall with a pH of about 4.2 an irregular "step" of 0–0.3 micrometers was found in the event surface recession sample on highly polished marble half briquettes, although no detectable recession was observed on the more porous Salem limestone. Measureable effects on the two types of test stones over the 10-year period of the experiments seem assured.

This news item was contributed by Susan I. Sherwood, *Preservation Assistance Division, National Park Service, Washington, D. C., and* Bruce R. Doe, *U.S. Geological Survey, Reston, Va.*

Marginal Ice Zone

Preliminary reports from the 1984 Marginal Ice Zone Experiment (MIZEX 84), said to be the "largest coordinated Arctic experiment conducted in the marginal ice zone," are now available. Over 200 scientists and technicians, utilizing seven ships, eight remote sensing/meteorological aircraft, and four helicopters, converged on the Arctic last May to study the mesoscale processes responsible for the advance and retreat of the Arctic ice margin.

Much of the data collected will be used to answer basic questions such as what factors influence the position, movement, and melting of the ice edge. Modelers will use the data to improve predictions of the motion and behavior of the Arctic marginal ice. Each year the polar ice field can migrate to the north or south as much as 600 km. New surface and boundary conditions can affect weather patterns of the entire northern hemisphere.

Ten countries—Canada, Denmark, the Federal Republic of Germany, Finland, France, Ireland, Norway, Sweden, the United Kingdom, and the United States—took part in the experiment, which was conducted from May 18 through July 30 in the Fram Strait area between Greenland and Svalbard. The USNS *Lynch* began MIZEX 84 in May with the deployment of an array of current meters and an acoustic source in the open water areas of the Fram Strait. An open water CTD (Conductivity, Temperature, and Depth) transect also was completed.

Ice dynamics and ice physics studies were conducted from the *Polarqueen*, *Polarstern*, and *Kvitbjorn*. These studies included extensive tracking of an array of ARGOS drifting oceanographic-meteorologic buoys and transponders. Ocean current data was collected by such instruments as subsurface drifters, surface ARGOS buoys, and current meters anchored and suspended from ice floes. For synoptic characterizations of the marginal ice zone, extensive passive-active microwave remote sensing investigations were conducted by both aircraft and in situ platforms.

In late November, scientists involved in MIZEX met at the Naval Postgraduate School in Monterey, Calif., to plan for the analysis of data and to begin initial development of a plan for future MIZEX programs.

Attrition of NASA Scientists

During the past 3½ years the number of physical scientists employed by the National Aeronautics and Space Administration (NASA) has dropped by more than 15%. The number of mathematics personnel also dropped by about 13%. NASA says these figures represent a trend to increase the agency's emphasis on its primary activity—aerospace engineering—that began with the completion of the Apollo missions.

For the same period the number of NASA personnel falling into the categories of aerospace engineering and electronic engineering increased slightly—by 1.2% and 3.1%, respectively. The decrease in both total NASA personnel and total scientific work force was about the same: NASA's scientific work force declined about 2.8%, compared with a total agency work force decrease of 2.9%.

These findings are contained in a study conducted by the U.S. General Accounting Office (GAO), "Attrition of Scientists and Engineers at Seven Agencies," on employment levels of scientific personnel at seven agencies between September 30, 1979, and June 30, 1983.

Of the agencies studied, NASA lost by far the fewest scientific and engineering personnel. Only one agency, the National Institutes of Health (NIH), showed any increase in its scientific personnel. NIH's scientific work force grew by 3.2%. Overall, NIH increased its total work force by about 7% during the period of the study. The largest decrease in both total agency work force and scientific personnel was felt by the Consumer Product Safety Commission (CPSC), which experienced decreases of 36.7% and 31.5%, respectively.

EOS

Transactions, American Geophysical Union

The Weekly Newspaper of Geophysics

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Eos: The Greek goddess of dawn, representing for AGU the new light continually being shed by basic geophysical research on the understanding of our planet and its environment in space.

Cover. A part of the Materials Research Exposure Site of the National Acid Precipitation Assessment Program, which is being constructed on top of the West End Branch of the Washington, D. C., Library. In the foreground is some pollution monitoring equipment from the Environmental Protection Agency. In the background are exposure racks for materials: Farthest back are the stone exposure racks, with the runoff experiments to the right and briquettes for destructive testing to the left. The covered/uncovered metals rack will be placed in front of the stone exposure racks to the right and the paint exposure rack to the left. In front of these racks are two wet/dry bucket collectors. The one to the left is being automated. In front of the wet/dry collectors (not shown) is an uncovered metals exposure rack that has been in place for over 2 years. The tall building behind the racks and across the street is Columbia Hospital for Women. (Photograph courtesy of Deborah Dwornik, U.S. Geological Survey, Reston, Va.)

Recent Ph.D.'s

Eos periodically lists information on recently accepted doctoral dissertations in the disciplines of geophysics. Faculty members are invited to submit the following information, on institution letterhead, above the signature of the faculty advisor or department chairman:

(1) the dissertation title,
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(3) name of the degree-granting department and institution,
(4) faculty advisor,
(5) month and year degree was awarded.

If possible, include the current address and telephone number of the degree recipient (this information will not be published).

Dissertations with order numbers, and many of the others listed, are available from University Microfilms International, Dissertation Copies, P.O. Box 1764, Ann Arbor, MI 48106.

Hydrology

Multiobjective Optimization of Stormwater Detention for Stream Channel Protection, **Charles J. Richman**, Dept. of Geography and Environmental Engineering, The Johns Hopkins Univ. (Charles S. ReVelle), October 1984.

Statistical Characterization and Numerical Simulation of a Fracture System: Application to Groundwater Flow in the Stripa Granite, **Alain Rouleau**, Dept. of Earth Sciences, Univ. of Waterloo (John E. Gale), October 1984.

Ocean Sciences

Multi-Property Modeling of the Marine Biosphere in Relation to Global Carbon and Climate Cycles, **Tyler Volk**, Dept. of Applied Science, New York Univ. (Martin I. Hoffert), June 1984.

Seasonal Thermohaline Stratification and Shelf Water – Slope Water Interaction in the Middle Atlantic Bight, **Frank Alkman III**, Dept. of Geological Sciences, Columbia Univ. (Arnold L. Gordon), October 1984.

Solid Earth

A Comparison of Seismic Properties of Young and Mature Oceanic Crust, **Michel Bee**, Dept. of Geophysics, College of Oceanography, Oregon State Univ. (Randy Jacobson), March 1984.

Crustal Structure and Seismicity of the Gorda Ridge, **Ariel E. Solano-Borego**, Dept. of Geophysics, College of Oceanography, Oregon State Univ., October 1984.

Geologic Interpretation of Remote Sensing Data for the Martian Volcano Ascraeus Mons, **James Ray Zimbelman**, Dept. of Geology, Arizona State Univ. (Ronald Greeley), December 1984.

Space Science

Jupiter's Ring System Resolved: Physical Properties Inferred from the Voyager Images, **Mark R. Showalter**, Dept. of Astronomy, Cornell Univ. (Joseph A. Burns), January 1985.

Correction

The earthquakes table in "Geophysical Events" (*Eos*, November 27, 1984, p. 1196) listed an October 18 earthquake in Senkaya, eastern Turkey, at 42.50°W longitude. The correct longitude is 42.50°E. This report is an excerpt from the Smithsonian Institution's *SEAN Bulletin, 9*(10), October 31, 1984.

Books

Geochemical Aspects of Radioactive Waste Disposal

D. G. Brookins, Springer-Verlag, New York, xiii + 347 pp., 1984, $44.50.

Reviewed by Judith B. Moody

The author's stated purpose in writing this book is to summarize the large number of government-sponsored research reports on the geochemical aspects of high-level nuclear waste isolation. Although this book has a 1984 publication date, the majority of the cited documents were published before 1982. Unfortunately, passage of the Nuclear Waste Policy Act (NWPA) of 1982 and its signing into law by President Reagan (January 1983) [*U.S. Congress*, 1983] has significantly altered the U.S. Department of Energy (DOE) Civilian Radioactive Waste Management (CRWM) Program. Therefore this book does not accurately reflect the present U.S. program in geologic disposal of high-level nuclear waste. For example, chapter 2, "Radioactive Waste Management," is almost 3 years out of date in a field that is changing rapidly (see *U.S. DOE* [1984*a*] for the current status of the CRWM Program). Additionally, the source material, which forms the input for this book, is chiefly grey literature, i.e., the referenced documents may or may not have undergone peer review and therefore do not represent the technical judgment of the scientific community. Also, this book only presents a selective sampling of information because the literature cited does not include a representative selection of the widespread available literature on this topic.

The geochemical aspects covered in this book are natural radiation effects (chapter 3), the different types of radioactive waste (chapter 4), generic and specific geologic sites (chapters 6 and 7), applications of geochronology in potential element mobility (chapter 6), use of natural analogs (chapter 11), waste form durability (chapter 12), the engineered barrier system (chapter 13), and uranium mill tailings (chapter 10). This range of addressed topics clearly outlines the importance of geochemistry to the CRWM Program, a position also emphasized by U.S. Nuclear Regulatory Commission (NRC) [*Apps et al.*, 1983] and other geoscientists [*Bird and Fyfe*, 1982].

The treatment of most subjects is simplistic and inadequate because of the necessity for the work accomplished in the CRWM Program to meet regulatory requirements [*U.S. NRC*, 1983*b*; *U.S. EPA*, 1982] and those requirements specified by the NWPA, including the siting guidelines [*U.S. DOE*, 1984*b*]. A few specific examples from chapters 6, 7 and 11 are treated below.

Issues related to geologic siting are addressed in a cursory fashion in chapters 6 and 7. The author states (p. 69) that "Of the many rocks available on the earth's surface, the geologic conditions are best met by bedded salt, dome salt, granites, basalt, argillaceous rocks and tuffaceous rocks." From that general statement, which includes a significant percentage of the rocks in the earth's crust, the reader is strongly led to think that any crustal rock could be used as a site for a high-level nuclear waste repository. Examination of the *U.S. DOE* [1982] and *U.S. NRC* [1983*a*] documents pertaining to the geologic site characterization of the Hanford basalt site will demonstrate the complexity of meeting the requirements and specifications for characterizing a specific site. Adequate geologic, hydrologic, and geochemical characterization of any site (regardless of host rock type) will require the best scientific and engineering knowledge and data acquisition (integrated laboratory, field, in situ testing, and modeling efforts) in order to meet the requirements governing the CRWM Program.

The author states in his preface that natural analogs will be emphasized wherever possible. The term "natural analog" is applied to observations of the geologic record as it is preserved in rocks, which compose the earth's crust, to obtain information on material's stability as applied to the engineered barrier system (waste form, canister overpack material, any potential backfill material) and the host rock. Natural analogs can also be studied to evaluate the potential migration/retardation behavior of radionuclides during geologic time frames (i.e., of the order of millions of years). Major topics covered in chapter 11 on natural analogs include specific geologic examples and the application of Eh-pH diagrams. Figure 1 illustrates the problems that can occur in attempting to utilize Eh-pH diagrams as a predictive tool for geochemical radionuclide behavior because (1) calculations are done assuming equilibrium constraints with a poorly known thermochemical data base at a certain set of fixed conditions (constant temperature, pressure, and fluid composition) and (2) the assumption of equilibrium may not be applicable to the near-field geochemical conditions in a high-level nuclear waste repository where the effects of heat and radiation on the host rock and engineered barrier system will require consideration of nonequilibrium kinetic reactions. *Lindberg and Runnels* [1984] have also shown that most ambient surface waters are not in a state of internal redox equilibrium. They have therefore raised the issue of whether calculated Eh-pH diagrams should be utilized for prediction of radionuclide behavior even in the ambient far-field groundwaters at a specific site because Eh is not an equilibrium variable in those groundwaters.

Books *(cont. on p. 1212)*

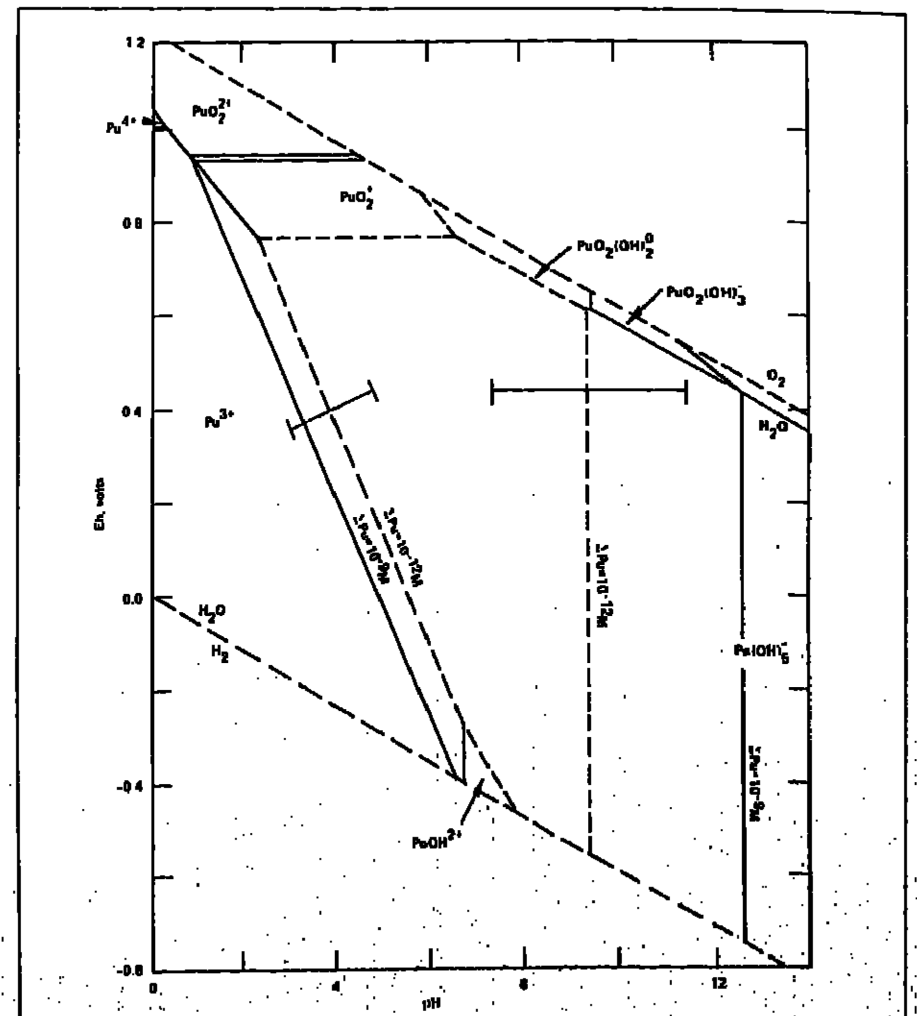

Fig. 1. Eh-pH diagram calculated at 25°C, 0.1 MPa by K. Krauskopf in the work of *Eisenbud et al.* [1981] for plutonium complexes in equilibrium with crystalline PuO_2 (utilizing largely the data from *Allard et al.* [1980] for plutonium). Solid lines outline the field where total dissolved Pu is less than 10^{-9} molar; dashed lines where total dissolved Pu is less than 10^{-12} molar. Error bars are placed on the two plutonium lines to indicate the degree of uncertainty in the basic thermochemical data from which the diagram was constructed; unmarked lines have uncertainties similar to the left-hand error bar. In other words, the lines should be replaced by bands the width of the bars, but this was not done for better clarity in the diagram [from *Moody*, 1982].

Books *(cont. from p.1211)*

The author states (p. 231) that "Studies at the Oklo Natural Reactor site show a remarkable ability of the Oklo rocks to retain fission products, actinides, and actinide-daughter products." The problem with that statement in terms of the CRWM Program is that it makes the reader wonder how the geochemical environment at Oklo (Gabon, West Africa) compares to the geochemical environment in any of the U.S. potential sites [*DOE*, 1984a]. What was the geochemical environment at the uranium mine at Oklo? Has it been adequately characterized? Has that environment been altered by other superimposed geologic events? In addition to Oklo, the author discusses contact metamorphic zones (Eldora-Bryan and Alamosa River Stocks, Colorado). Utilization of contact metamorphic zones as natural analogs for geochemical radionuclide behavior raise these issues:

1. Does the thermal gradient at a contact metamorphic zone defined by an igneous dike intrusion adequately mimic the thermal gradient expected in a nuclear waste repository as a function of time?

2. Does the contact metamorphic cooling time adequately reflect the cooling history, which is an expected condition in a nuclear waste repository?

3. Are the geochemical processes at a contact metamorphic zone similar to that expected in the near field of a high-level nuclear waste repository?

Natural analog studies can provide important information for performance assessment of radionuclide geochemistry, but their application will be useful only if their geochemical environment can be transferred to ambient site-specific and near-field geochemical conditions.

In conclusion, this book does not achieve the goals specified in its preface and introduction. Technical conservatism, as well as good scientific and engineering judgment, is essential, given the complexity of geochemical problems involved in the siting and performance assessment of any potential geologic high-level nuclear waste site. Geochemistry, as a subdiscipline of the earth sciences, has a significant role in the high-level nuclear waste program. That role requires definition of geochemical issues, gathering the necessary data, and then utilizing those data for the long-term performance assessment of the geologic site and the engineered barrier systems. Unfortunately, this book does not meet that challenge.

Author's Note. The views presented in this book review are solely those of the author.

References

Allard, B., H. Kipatsi, and J. O. Liljenzin, Expected species of uranium, neptunium, and plutonium in neutral aqueous solutions, *J. Inorg. Nucl. Chem.*, *42*, 1015–1027, 1980.

Apps, J. A., C. L. Carnahan, P. C. Lichtner, M. C. Michel, D. Perry, R. J. Silva, O. Weres, and A. F. White, Status of geochemical problems relating to the burial of high-level radioactive waste, 1982, *Rep. NUREG/CR-3062*, 363 pp., U.S. Nucl. Regulatory Comm., Washington, D. C., 1983.

Bird, G. W., and W. S. Fyfe (eds.), Geochemistry of radioactive waste disposal, *Chem. Geol.*, *36*, 1–214, 1982.

Eisenbud, M., W. Lei, R. Ballad, K. Krauskopf, E. Penna Franca, T. L. Cullen, and P. Freeborn, Mobility of thorium from the Morro do Ferro (abstract), in International Symposium on Migration in the Terrestrial Environment of Long Lived Radionuclides From Nuclear Fuel Cycle, *Rep. IAEA-SM-257/49*, Int. Atom. Energy Agen., Knoxville, TN, 1981.

Lindberg, R. D., and D. D. Runnels, Ground water redox reactions: An analysis of equilibrium state applied to Eh measurements and geochemical modeling, *Science*, *225*, 925–927, 1984.

Moody, J. B., Radionuclide migration/retardation, *Res. Dev. Technol. Status Rep., ONWI-321*, 61 pp., Off. of Nucl. Waste Isol., Columbus, Ohio, 1982.

U.S. Congress, Nuclear Waste Policy Act of 1982, *Public Law 97–425*, *pp. 10,101–10,226*, 97th Congress, 1st Session, 1983.

U.S. Department of Energy, Site characterization report for the Basalt Waste Isolation Project, *Rep. DOE/RL 82–3*, vols. 1 and 2, Washington, D. C., 1982.

U. S. Department of Energy, Annual report to Congress, 32 pp., Off. of Civilian Radioactive Waste Manage., Washington, D. C., 1984a.

U.S. Department of Energy, General guidelines for recommendation of sites for nuclear waste repositories, with concurrence by the U.S. Nuclear Regulatory Commission on June 22, 1984, *10 Code of Fed. Regul., Part 960*, Washington, D. C., 1984b.

U.S. Environmental Protection Agency, Proposed environmental standards for the management and disposal of spent nuclear fuel, high-level and transuranic radioactive wastes, *40 Code of Fed. Regul., Part 191*, Washington, D. C., 1982.

U.S. Nuclear Regulatory Commission, Draft site characterization analysis of the site characterization report for the Basalt Waste Isolation Project, *Rep. NUREG-0960*, vols. 1 and 2, Washington, D. C., 1983a.

U.S. Nuclear Regulatory Commission, Disposal of high-level radioactive wastes in geologic repositories: Licensing procedures, *10 CFR Part 60*, Washington, D. C., 1983b.

Judith B. Moody is with the Battelle Project Management Division of the Office of Nuclear Waste Isolation, Columbus, Ohio.

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For further information on faculty and active research projects, contact: Kevin Crowley, School of Geology and Geophysics, University of Oklahoma, 830 Van Vleet Oval, Norman, OK 73019.

University of Washington/Geophysics. Applications invited for a research faculty opening at the Assistant Professor level. Candidates are expected to establish innovative, high quality research programs in rock and mineral physics and to obtain funding (including salary) to maintain programs which should complement and/or augment existing programs in rock and mineral physics at the UW of Drs. J.M. Brown and Y. Sato-Sorensen.

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John C. Butler, Geosciences
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Physical Oceanographer/North Carolina State University. Applications are invited for a nine-month, state funded, tenure track position at the assistant or associate professor level in descriptive physical oceanography. The successful applicant will have a Ph.D., a background inocean circulation and state of the art instrumentation, and will be expected to develop a strong field program and teach graduate level courses. He or she will also have the opportunity of interacting with thirty-two departmental facuty in various areas in oceanography, meteorology and geology. Send curriculum vitae and the names of three references by January 31, 1985 to: Dr. G.S. Janowitz, Chairman, Search Committee in Physical Oceanography, Department of Marine, Earth and Atmospheric Sciences, Box 8208, Raleigh, NC 27695–8208, Telephone 919-737-3711.

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Physical Oceanographer/University of South Carolina. The Marine Science Program and Department of Geology anticipate a tenure track faculty position in physical oceanography to begin in the academic year 1985–86. Salary and rank are dependent upon qualifications; however, preference will be given to applicants at the Assistant Professor level. The Program seeks an applicant with specialty in either theoretical, numerical or field oceanography. Active oceanographic research at USC includes studies of estuarine and coastal circulation, mixing, and transport processes; thermohaline and deep ocean mixing; paleo oceanography and circulation; and physical-biological coupling in nearshore ecosystems. Applicants must have a Ph.D. degree, substantial qualifications in marine research, and a strong commitment to teaching and research. Submit resume, a brief statement of research interests and names/addresses/phone numbers of three references to: Dr. Björn Kjerfve, Chairman, Search Committee, Marine Science Program, University of South Carolina, Columbia, SC 29208 before 31 January 1985.

The University of South Carolina is an equal opportunity/affirmative action employer.

Geophysicist. Ph.D or M.S. in geophysics. The position requires a broad background in theoretical seismology, applied mathematics, and physics. Experience in scientific programming using FORTRAN is desired. Familiarity with statistics, time series analysis and numerical methods and the UNIX operating system is desirable. Preference will be given to applicants with publications.

Contact: Dr. Zoltan Der or Dr. Keith McLaughlin
314 Montgomery Street
Alexandria, VA 22314
(tel.: 703-836-3882)

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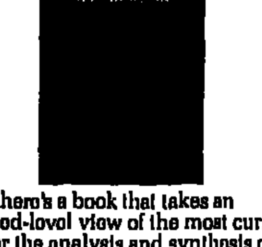

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Faculty Positions/The Pennsylvania State University. The Department of Geosciences invites applications for three (3) tenure track faculty positions in any of several fields of specialization. The faculty rank associated with each position is presently open, although salary funds currently available are sufficient for, at most, one senior full professorship. The successful candidates must be, or have demonstrated the potential to become, nationally recognized leaders in their fields. They must also have an interest in teaching and advising graduate and undergraduate students. Instructional and research areas in which particular needs have been identified include, but are not necessarily limited to: aqueous geochemistry, with emphasis on the kinetics of low-temperature rock-water interactions; experimental petrology, with emphasis on the equilibrium and kinetic properties of petrological systems; heavy isotope geochemistry, with emphasis on element distribution systematics and their geological applications; hydrogeology, with emphasis on the physics of fluid flow and mass transport through porous media; mineral physics/mineralogy, with emphasis on petrological applications of crystallochemical methods; rock physics, with emphasis on the dynamical properties of upper-crustal rocks; sedimentary geochemistry, with emphasis on diagenesis of fine-grained sediments and organic matter; and structural geology, with emphasis on regional tectonics.

The selection of persons to fill these three positions will be based in part on the extent to which their future research efforts will complement and further strengthen our programs in Geochemistry and Mineralogy, Geology, and Geophysics. Qualified persons should, therefore, include a brief description of their future research objectives with their resumes and the names of three references to:

C. Wayne Burnham, Head
Department of Geosciences
The Pennsylvania State University
503B Deike Building
University Park, Pennsylvania 16802.

The deadline for applications is April 30, 1985.

An Equal Opportunity/Affirmative Action Employer.

Assistant/Associate Professor of Geophysics. Applications are invited for a tenure track position as assistant or associate professor of geophysics in the College of Oceanography at Oregon State University to complement the present eight-member geophysics faculty. Candidates must have a PhD or equivalent and a demonstrated ability to conduct independent research in theoretical or observational geophysics sustained by external research funding. Most solid earth geophysics research specialties will be considered. Duties will include teaching graduate courses, supervising graduate students and developing a grant-funded research program. Those interested should submit a resume, names of three references and a brief statement of research plans by February 28, 1985 to:

Acting Dean
College of Oceanography
Oregon State University
Corvallis, OR 97331.

Oregon State University is an affirmative action/equal opportunity employer and complies with Section 503 of the Rehabilitation Act of 1973.

NASA/Goddard Space Flight Center. The Earth and Space Sciences Directorate is seeking a highly qualified and motivated research scientist to manage a broad program of basic and applied research devoted to understanding processes occurring on the surface of the earth as they involve the biosphere, soils, and land-air interactions. Salary range ($50,495 to $65,642) depending on qualifications and experience. All candidates must possess professional experience or graduate education in an appropriate field of engineering, physical science, or mathematics with documented experience in research to include publications in scientific or technical journals. In addition, candidates must demonstrate proof of having managed research programs and projects. At least one year of the required experience must be at a level of difficulty comparable to the GS-14 level in the federal service. Candidates should contact: Michael Parrish, NASA/Goddard Space Flight Center, Personnel Division, Code 225-MP, Greenbelt, Maryland 20771, 301-344-7918. U.S. Citizenship is required.

Equal Oppotunity Employer.

University of South Carolina. Two year postdoctoral research assistant position anticipated. Person should have a strong background in structural geology of complexly deformed regions along with an interest in geologic mapping and integration of diverse kinds of geologic and geophysical data. Starting date as early as January 15, 1985. Closing date for applications December 31, 1984. Applications with vitae, interests and possible referees should be sent to Prof. Robert D. Hatcher, Jr., Department of Geology, University of South Carolina, Columbia, SC 29208.

The University of South Carolina is an affirmative action/equal opportunity employer.

Petrologist/Virginia Poytechnic Institute and State University. The Department of Geological Sciences at Virginia Tech invites applications for two tenure track faculty appointments in Igneous or Metamorphic Petrology. Applicants must demonstrate a strong research record in quantitative petrology; preference will be given to those with experience in the theoretical and experimental aspects of petrology. All faculty members at Virginia Tech are expected to provide quality teaching at the undergraduate and graduate levels, supervise M.S. and Ph.D. theses, and conduct an active program of research and publication.

Applicants should send a letter of application, academic vita and names and addresses of three references to:

D.A. Hewitt
Department of Geological Sciences
Virginia Tech
Blacksburg, VA 24061.

The appointments will begin in September 1985 and candidates are expected to have completed requirements for the Ph.D. by that time. The deadline for receipt of applications is January 1, 1985.

Virginia Tech is an equal opportunity/affirmative action employer.

Isotope Geochemist or Economic Geologist/University of Washington. The Department of Geological Sciences invites applications for a tenure track appointment at the Assistant Professor level with specialization in Isotope Geochemistry or Economic Geology. The position will be available in the Fall of 1985. Candidates must hold a Ph.D. degree and be committed to establishing a nationally prominent research program. Applicants in isotope geochemistry should have experience in the measurement of isotopic abundances in radiogenic systems, and in the application of isotopic data in solving problems in petrology, crust and mantle evolution or cosmochemistry. Applicants in economic geology should have a strong background in geochemistry with particular research interests in the application of chemical principles to the processes of ore genesis. Candidates will be expected to teach at both the undergraduate and graduate levels and to supervise graduate research.

Send letter of application (including description of research interests), curriculum vitae, and names of four referees to Chairman, Search Committee, Department of Geological Sciences, AJ-20, University of Washington, Seattle, Washington 98195.

The University of Washington is an Affirmative Action/Equal Opportunity Employer.

SCIENTIST III OR SENIOR SCIENTIST

The National Center for Atmospheric Research seeks an advanced level scientist to conduct independent and collaborative research using a spectrum of techniques to increase understanding of the structure and evolution of mesoscale convective systems within our Convective Storms Division. The individual will assist in determining the long-term goals of the division and its Mesoscale Interactions Group (MIG); collaborate with scientists at NCAR and elsewhere; publish regularly in scientific journals; participate in scientific meetings; and participate in the planning and execution of current and future large-scale field experiments. As Senior Scientist, will be expected to take a leadership role in the above activities; effectively manage scientific, technical and support staff per established policies and affirmative action programs; and may act as head of the MIG. Requirements include: expertise in data analysis and conceptual modeling or numerical modeling; nationally recognized record of independent or collaborative accomplishments and publications; demonstrated leadership in one or more subfields of the atmospheric sciences involved with mesoscale meteorology, individual convective clouds or microphysics; and sufficient breadth and depth to initiate productive interactions with scientists of related but not necessarily congruent specialties. Additional requirements for Senior Scientist include: expert scientific reputation established nationally and internationally as shown by publications in one or more subfields of the atmospheric sciences involved with mesoscale meteorology as described above; demonstrated breadth and depth of knowledge necessary to sustain the long-term scientific leadership of NCAR; extensive record of exceptional research, leadership and service; and demonstrated skill in managing staff, particularly scientists.

Salary ranges are: Scientist III, $39,030–58,544/year
Senior Scientist, $40,998–68,330/year

To apply, send resume, publications list and references to:

N.C.A.R.
P.O. Box 3000, Boulder, CO 80307
Attention: Deborah Koepke
An Equal Opportunity/Affirmative Action Employer

NCAR
National Center for Atmospheric Research

Sedimentologist-Oceanographer/Texas A&M University. Applications are invited for a tenure track faculty position in the general field of marine sedimentology. The position will involve graduate level teaching and supervision of graduate student research. The successful applicant will have demonstrated excellence in or a strong potential for independent research in the field of marine sedimentation. The position is available beginning September 1, 1985. Salary and rank will be commensurate with experience and qualifications. Applicants are invited to submit curricula vita, copies of publications, names of three persons who may serve as references, and a letter outlining the applicant's teaching and research interests by December 31, 1984, to Robert O. Reid, Distinguished Professor and Head, Department of Oceanography, Texas A&M University, College Station, Texas 77843.

Texas A&M University is an affirmative action/equal opportunity employer.

Postdoctoral Fellowship/Lamont-Doherty Geological Observatory. A postdoctoral fellowship for research in Physical Oceanography or Air-Sea Interaction Studies is available at Lamont-Doherty Geological Observatory of Columbia University. The successful candidate may pursue any topic covered by the broad categories stated, including atmospheric studies relevant to questions of large scale air-sea interactions. The candidate would work with the physical oceanography group, which has particular strengths in tropical, polar and coastal oceanography, and in numerical modeling. The fellowship carries a stipend of $26,000. Send a statement of research interests, curriculum vitae and the names of three references to:

Margaret Swan
Office of the Director
Lamont-Doherty Geological Observatory
Palisades, New York 10964.

Columbia University is an affirmative action/equal opportunity employer.

Theoretical Space Plasma Physicist. The Space Sciences Laboratory of the University of California at Berkeley solicits applications for a renewable three-year appointment as a Senior Fellow with Principal Investigator status. We are seeking a Ph.D. physicist who has demonstrated leadership and creativity in space plasma theory and who will develop his/her own research group and participate in educational activities of the academic departments. The level, to be determined at the time of appointment, will be Assistant, Associate, or Full Research Scientist depending upon qualifications.

Vita, bibliography, statement of prospective research program and three letters of reference should be sent by February 1, 1985 to P. Buford Price, Director, Space Sciences Laboratory, University of California, Berkeley, CA 94720

The University is an equal opportunity/affirmative action employer.

Physical Oceanographer/Research Corporation/University of Hawaii. The newly established Tropical Ocean-Global Atmosphere (TOGA) Sea Level Data Center has an opening for a research scientist. The applicant is expected to work on the observational and theoretical aspects of sea level variations and their dynamics in the tropical ocean. Participation in the operation of the center will also be required. The candidate must hold a Ph.D. in Physical Oceanography or a related field and should have a strong background in theoretical oceanography (Ocean Dynamics) and must be able to conduct independent research. Salary starting range $30,000 to $35,000 dependent upon qualifications. Applications with curriculum vitae and names and addresses of three references should be sent to:

Dr. Klaus Wyrtki
Department of Oceanography
University of Hawaii
Honolulu, Hawaii 96822

Starting date no later than April 1985.
Deadline for applications is January 31, 1985.
An equal opportunity/affirmative action employer.

UNIVERSITY OF IOWA DEPARTMENT OF PHYSICS AND ASTRONOMY

The Department of Physics and Astronomy anticipates openings for two tenure-track assistant professors in August 1985. Preference for one of these positions will be given to an experimentalist. In an exceptional case a term or tenured appointment at the associate professor or professor level will be considered. In addition, one or more openings for visiting faculty members at any level are anticipated. Current research interests in the department are radio and optical astronomy and the following specialities in physics: atomic, condensed matter, elementary particle, laser, nuclear, plasma, and space physics. Faculty duties include undergraduate and graduate teaching, guidance of research students, and personal research. Interested persons should submit a résumé and a statement of research interests and arrange for three letters of recommendation to be sent to: **Search Committee, Department of Physics and Astronomy, The University of Iowa, Iowa City, IA 52242.**

The University of Iowa is an equal opportunity/affirmative action employer.

THE AEROSPACE CORPORATION SPACE SCIENCES LABORATORY

The Space Sciences Laboratory of The Aerospace Corporation invites applications for a full-time position in the Atmospheric Sciences Department to carry out research in upper atmospheric and ionospheric physics and the effects of the near-earth space environment on space systems. Ongoing activities include investigations of the earth's mesosphere, thermosphere and ionosphere and their interactions with the magnetosphere. These investigations make use of both ground and space-based instrumentation and involve the collection, analysis and theoretical interpretation of data of basic scientific interest.

The applicant will be expected to participate in individual and collaborative research projects involving both experimental and theoretical components. A PhD and, preferably, 2-5 years of experience in one or more of the following areas is desired: space plasma physics theory and/or simulation, auroral and airglow processes, radiation transport, atomic and molecular spectroscopy, ionospheric physics, upper atmospheric dynamics and chemistry, optical and electro-optical instrumentation, modeling and analysis of spacecraft/rocket data, especially as related to remote sensing and allied theoretical disciplines.

Salary will be commensurate with experience. Applicants should send a letter of interest and a resume including the names of three references to:

The Aerospace Corporation

Dr. Joe M. Straus
Space Sciences Laboratory M2/255
Dept. 00624
P.O. Box 92957
Los Angeles, CA 90009

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CHIEF LAND SCIENCES BRANCH U.S. DEPARTMENT OF COMMERCE NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION (NOAA)

GS-1301-14

SALARY RANGE $42,928 TO $55,807

The Climate and Earth Sciences Laboratory, National Environmental Satellite, Data, and Information Service (NESDIS), NOAA, announces a vacancy for the position of Chief, Land Sciences Branch. The Climate and Earth Sciences Laboratory is responsible for applying satellite observations to problems in the atmospheric, oceanic and land sciences. The Land Sciences Branch uses imagery and radiometric observations from meteorological and land resource satellites for studies in climatology, hydrology, glaciology, and agriculture. It is anticipated that the Land Sciences Branch will participate in the recently initiated International Satellite Land Surface Climatology Project. Branch scientists: 1) develop algorithms for deriving land surface variables from satellite radiance observations, 2) test, validate and apply these algorithms, and 3) perform research on land surface processes using the satellite based measurements. Examples of land variables of interest include snow and ice, skin temperature, surface radiation budget, soil moisture, vegetation cover, and hydrological parameters.

The successful applicant will direct the activities of the Branch and manage its resources, including research grants/contracts with external institutions. He will also actively engage in personal research in one of the land science areas. The successful applicant must have a record of scientific achievement on the application of remote sensing to the above stated problems, as evidenced by publications in the scientific literature. The position requires a Ph.D. in the physical sciences or equivalent and at least five years or relevant experience. Familiarity with programming of mainframe computers and experience with interactive image processing systems are also desirable.

Persons interested in applying must request a copy of the vacancy announcement, which contains qualification requirements, by writing to NOAA, FB4, Room 2051, Washington, D.C. 20233, ATTN: RAS/DC24, Barbara Jones, or calling 301/763-1986. Applications should be prepared on Standard Form 171.

Department of Commerce is an Equal Opportunity Employer. U.S. Citizenship required.

Postdoctoral Associate/Meteoritic Studies. The Harvard-Smithsonian Center for Astrophysics has a postdoctoral opening for a well-qualified recent Ph.D. who wants to advance our understanding of the origin of planets by carrying out petrologic studies of meteorites. The appointment is for one year (renewable for a second year), beginning August 1, 1985. Familiarity with automated microprobe analysis is essential; some previous exposure to cosmochemistry is desirable. Please send inquiries to Dr. John A. Wood, Smithsonian Astrophysical Observatory, 60 Garden Street, Cambridge, MA 02138.

The Smithsonian Astrophysical Observatory is an equal opportunity employer.

Seismologist/University of Utah. The Department of Geology and Geophysics at the University of Utah seeks applicants for a tenure track faculty position in seismology at the assistant to associate professor level. Applicants with backgrounds and specialties in seismic imaging, seismic reflection or theoretical seismology will be given preference. The individual will be expected to teach undergraduate and graduate courses and to pursue an active research program with graduate students. A seismic imaging laboratory with a VAX 11/730, FPS array processor, plotters, and processing and synthetic seismogram software is available to the successful candidate. Current research in seismology includes: earthquake research utilizing a PDP 11–70 computer; monitoring of the Intermountain seismic belt by an 85 station telemetered network utilizing an on-line PDP 11–34 computer; major experiments in seismic refraction and reflection profiling for crustal structure; and allied research in tectonophysics. The opportunity exists to participate with several other faculty in an integrated program of tectonics, seismology and sedimentology directed toward crustal studies and petroleum exploration. The geophysics component of the department has active research and teaching programs in electrical and electromagnetic methods, thermal properties of the earth, potential fields, and seismology. The department has close associations with the numerical analysis and data processing groups in computer science, electrical engineering and mathematics. The closing date for applications is December 31, 1984, and the appointment date is September 15, 1985. A Ph.D. is required for this position. Applicants should submit a vita, transcripts, a letter describing his/her research and teaching goals and names of five persons for reference. Qualified persons should send their applications to William P. Nash, Chairman, Department of Geology and Geophysics, University of Utah, Salt Lake City, Utah 84112–1183.

The University of Utah is an equal opportunity/affirmative action employer.

Texas Tech University/Geophysicist or Clastic Sedimentologist. The Department of Geosciences at Texas Tech University seeks applications for a tenure track position in the fields of geophysics or clastic sedimentology to begin August 1985. Rank and salary will be commensurate with qualifications. The Ph.D. is required. Entry-level applicants will be given preference. The primary responsibilities would be to teach both graduate and undergraduate courses in geophysics or depositional systems and sedimentology, higher specialty, and introductory geology. The person will be expected to initiate a research program and to direct MS and Ph.D. graduate students. Send a letter of application with complete curriculum vitae and names of three references to Dr. Alonzo D. Jacka, Chairman of Geosciences, P.O. Box 4109, TTU, Lubbock, TX 79409.

Texas Tech is an equal opportunity/affirmative action employer. Applications deadline: January 31, 1985.

Faculty Position/Marine Remote Sensing. The Applied Ocean Science Program at the University of Delaware's College of Marine Studies invites applications for a tenure track faculty position in marine remote sensing and optical physics. Teaching at the graduate level will be required, including courses on the theory and marine applications of electromagnetic waves. The successful candidate will be expected to develop a funded research program involving graduate students. This individual will have the opportunity to interact with ongoing research in remote sensing of wetlands biomass and estuarine productivity; coastal circulation and fronts; air-sea interaction; spectral/spacial analysis of satellite imagery; electromagnetic and sound wave interaction with suspended particles; and Laser Doppler characterization of marine plankton. Applicants should hold a Ph.D. in the physical sciences or engineering, with at least three years of experience in fundamental research on remote sensing. It is anticipated that the appointment will be at the assistant professor level, but applications from more senior persons are welcome. Applicants should send curriculum vitae, pertinent reprints, and names of three references by January 31, 1985 to: Dr. V. Klemas, Director, Applied Ocean Science Program, College of Marine Studies, UNIVERSITY OF DELAWARE, Newark, Delaware 19716, 302-451-2336.

The University of Delaware is an Equal Opportunity/Affirmative Action Employer.

University of Illinois at Chicago. The Department of Geological Sciences seeks to fill tenure track positions probably, but not necessarily, at the rank of assistant professor, probably effective Fall, 1985, pending budgetary approval, in one or both of the following disciplines: 1) Geophysics (preferably in seismology); 2) sedimentary geochemistry. Each person is expected to teach both undergraduate and graduate courses and to conduct a vigorous research program, including the supervision of graduate students. PhD required. Applicants should submit a detailed resume, names and addresses of three references, and an explanatory statement of research and teaching interests by February 28, 1985, to Robert DeMar, Department of Geological Sciences, University of Illinois at Chicago, Chicago, Illinois 60680. Representation of the Department will be at the AGU Fall Meeting in December.

The University is an equal opportunity/affirmative action employer.

Supervisory Oceanographer, GM-1360-15. The Office of Oceanography and Marine Services, NOAA/National Ocean Service, located in Rockville, Maryland is seeking individuals with backgrounds in oceanography and computer applications to serve as the Chief of the Tides and Water Levels Branch, Ocean Requirements and Data Analysis Division. DUTIES: establishes plans, production goals, priorities, and major work schedules for the Branch; has scientific and technical responsibility for the work performed by the Branch; serves as chief Federal negotiator for all Federal-State cooperative programs concerned with coastal and marine boundaries; presents papers and reports to scientific and engineering organizations, civic and educational groups, and the business community on behalf of the Administrator and Assistant Administrator of NOAA; serves as an authority on tides, sea level, water levels, and engineering, including operations and systems integration, both theoretical and applied; must have personal familiarity with all technical activities carried out within the Branch, including tide and water level measurements, data transfer, data processing, tidal datums, and user products and applications.

QUALIFICATIONS: applicants must have a minimum of a Bachelor's Degree in oceanography (or a related physical science discipline), or major study of at least 24 hours in oceanography combined with additional education and/or pertinent work experience in the field of oceanography to total four years of education and experience. In addition, applicants must have had three years of professional experience in, or directly related to, oceanography. SALARY RANGE: $50,495 to $65,643.

Interested applicants should submit a Standard Form (SF) 171, Personal Qualifications Statement, including a summary of their experience in the following areas: 1) International recognition as an authority in the field of tides and Great Lakes water levels; 2) Ability to represent the Federal government in extensive negotiations with foreign governments, judicial bodies, and other large organizations; 3) Ability to perform executive travel, both foreign and domestic; 4) Ability to manage a highly complex technical organization undergoing extensive transitions in roles and techniques of operation (i.e. contractor vs. in-house, automation vs. manual); 5) Ability to manage a service organization which must remain responsive to changes in user requirements; and, 6) Skill in written and oral communication.

Please send your SF-171 to: NOAA/NOS Personnel Branch: RAS/DC 25; 6001 Executive Blvd., Rockville, Maryland 20852; Attn: Mrs. B. Garcia. For more information, contact Captain Jeffries, NOAA, Rockville, MD, Telephone FTS 443-8487 or commercial 301-443-8487.

NOAA is an equal opportunity employer.

CHIEF HYDROGEOLOGIST

SHANNON & WILSON INC., a leading national geotechnical and applied geoscience consulting firm celebrating its 30th year, has an immediate opening for a Chief Hydrogeologist in the Seattle office. The successful candidate will direct the existing well-established groundwater discipline. The position requires national-class technical expertise, proven business development, and project management skills.

Applicants must have an advanced degree in Geology, or Hydrogeology, and over 15 years of direct experience in water resource development, groundwater modeling, contaminant hydrogeology, and allied geotechnical projects. Nuclear and hazardous waste experience is particularly desirable.

SHANNON & WILSON, INC.
Attn: Raymond P. Miller
P.O. Box C-30313
Seattle, WA 98103

EOE

University of Wisconsin—Madison. The Department of Geology and Geophysics invites applications for an anticipated tenure track position at the assistant professor level in applied geomorphology and/or hydrogeology commencing in August 1985. The applicant should be committed to developing a strong research program as well as teaching undergraduate courses in some aspects of engineering and environmental geology. The Ph.D. is required. Applicants with course work in engineering and an interest in the field application of geologic principles are especially encouraged to apply. Send letter of application outlining your professional goals, transcripts, resume, copies of publications, and three letters of reference to Dr. Mary P. Anderson, Department of Geology and Geophysics, Weeks Hall, University of Wisconsin, Madison, WI 53706. Closing date is January 1, 1985.

The University of Wisconsin is an equal opportunity/affirmative action employer.

Research Associate/University of Colorado. The Laboratory for Atmospheric and Space Physics has an opening for a research associate for an initial one-year period with high likelihood of extension. The position involves analysis of data from the infra-red radiometer on the Solar Mesosphere Explorer Satellite, and research involving middle atmosphere photo chemistry and dynamics. The extensive SME data base includes three years of global measurements of ozone, temperature water vapor, nitrogen dioxide and other parameters of the Earth's mesosphere and stratosphere. Applicants should possess a PhD and have a background in atmospheric sciences. Salary to be commensurate with experience. Applicants should submit complete vita, and the names of three references. Inquiries and applications should be directed to:

Professor Gary E. Thomas
Laboratory for Atmospheric and Space Physics
Campus Box 392
University of Colorado, Boulder, CO 80309

Applications are being accepted until July 1, 1985.

The University of Colorado is an equal opportunity/affirmative action employer.

Position in Geology/University of California. Position in Geology (with emphasis on applied geophysics), University of California, Riverside, California. The Department of Earth Sciences has an Assistant Professor/Assistant Research Geophysicist (50% instruction/50% research) opening beginning 1 September 1985. The appointment is a ladder faculty position. The faculty member would be expected to teach at both the undergraduate and graduate level in applied geophysics and to develop and conduct active research programs in such areas as: groundwater hydrology, reservoir assessment, geological engineering, and/or application of modern geophysical techniques to the solution of current earth sciences problems. Ph.D. is required. In addition to teaching and research, university and professional service are also expected of faculty members at the University of California. Applicants should submit a current curriculum vita with the names and addresses of three people who have agreed to provide references. Applications should be complete by February 15, 1985; however, late applications may be accepted until a successful candidate is appointed. Send applications to Dr. Shawn Biehler, Chair, Search Committee, Department of Earth Sciences, University of California, Riverside, CA 92521.

The University of California is an Equal Opportunity/Affirmative Action Employer. Female and minority applicants are urged to apply.

Research Assistant in Space Physics. Immediate opening for researcher at the Regis College Research Center in the dynamics of the earth's ionosphere and relationships to the near earth environment and the sun. Candidate must have a Ph.D. in physics or engineering with strong background in plasma physics. Work will principally consist of analyzing and interpreting data from satellites in the near earth environment. Research topics include plasma irregularities and turbulence, wave-particle interactions and field-aligned currents in the high latitude ionosphere. Work will be performed at the Air Force Geophysics Laboratory, Hanscom AFB, MA. Please send resume and list of references to:

Sr. Mary Anne Doyle
Regis College
Box 29
235 Wellesley Street
Weston, MA 02193

Regis is an equal opportunity employer.

USRA Internship Program: Remote Access to NASA/GLAS General Circulation Models. The Universities Space Research Association (USRA), in collaboration with the Goddard Laboratory for Atmospheres (LA: formerly Goddard Laboratory for Atmospheric Sciences, GLAS) of NASA/Goddard Space Flight Center announces a new short-term internship/visiting scientist program. Its purpose is to allow staff members of recognized academic institutions hands-on experience with the use and research applications of large codes already developed at the Global Modeling and Simulation Branch (GMSB). These codes include the GLAS Temperature Retrieval System, and the GLAS Analysis System, as well as other GCMs, limited-area and special purpose models, all of which will have been implemented on the CYBER 205 computer of the NASA High Speed Computer Facility (NHSCF). The selected researchers will work at NASA/GSFC under the one-to-one guidance of GMSB professional and support staff. The objective of the program is to give individual scientists the knowledge and experience necessary to permit them to carry out research using GMSB codes by remote terminal access to the NHSCF after returning home.

Appointments will be for a two to three month period. An applicant should submit a proposal to USRA describing in detail the intended use of remote access to LA atmospheric models. A proposer must have a NASA funded research program already in progress that requires this access, or must be planning to submit a proposal to NASA Headquarters for funding a project that has such a requirement.

Proposals for the LA-USRA internship program may be submitted at any time. Selection will be made semi-annually by a joint LA-USRA panel, based on the merit of the proposer's research program, and the value of LA remote-access training to the proposed research effort. Consideration will also be given to individuals whose involvement is through colleagues or graduate students.

Compensation is based on the principle of no-gain, no-loss for the appointee; details will be worked out on an individual basis.

For more information, or to submit a proposal, contact:

Dr. M.H. Davis
Universities Space Research Association
P.O. Box 3006
Boulder, CO 80307
303-449-3414
or
Dr. Eugenia Kalnay
Global Modeling and Simulation Branch
Laboratory for Atmospheres
NASA/Goddard Space Flight Center
Greenbelt, MD 20771
301-344-7482

Anticipated Seismology/Paleomagnetism/Tectonophysics: Louisiana State University. The Department of Geology is searching for candidates to fill as many as four positions in geophysics and two in tectonophysics. The principal interest is in persons specializing in theoretical and applied seismology. Expertise in wave propagation, tomography, and/or digital processing is especially sought. Outstanding candidates in paleomagnetism are also sought, with emphasis on tectonic applications. In tectonophysics, specialization in rock mechanics or numerical modeling is of interest.

At the present the Department has three geophysicists and by Spring, 1985, will have two structural geologists. The geophysics program has a VAX 11/750 computer, a Pre/Seis seismic data processing system, several seismic field acquisition systems, and numerous terminals and peripherals for the VAX and the University's IBM 3081 and 3033 systems. Plans for acquiring additional computer equipment are underway.

Successful applicants are expected to offer graduate and undergraduate courses in their specialties and to develop a strong record of funded research and publication. The positions are at the Assistant Professor level, but appointment at higher rank will be considered for candidates with appropriate experience.

Applicants should submit a vita, representative reprints, and a statement of teaching and research interests and arrange for three letters of recommendation to be sent to: Chairman, SPT Search Committee, Department of Geology, LSU, Baton Rouge, LA 70803-4101.

LSU IS AN EQUAL OPPORTUNITY/AFFIRMATIVE ACTION EMPLOYER.

Faculty Position in Ocean Acoustics. The Oceanography Department, Naval Postgraduate School, has a newly created tenure track position at the assistant or junior associate professor level in Ocean Acoustics. The applicant should have an earned Ph.D. with an academic background in oceanography, applied science or engineering, and experience in underwater acoustics, with ocean acoustic modeling or ocean acoustic field experiments. The successful candidate will be expected to teach one or two quarters per year, conduct sponsored research, and provide thesis supervision. A research vessel, close access to both shallow and deep water, excellent computer facilities, and instrumentation are available. Basic and applied research opportunities are abundant. The Environmental Acoustics Research Group of the Oceanography Department is actively engaged in Navy sponsored research, ranging from sensor studies to ambient noise prediction studies. A strong laboratory-based acoustics program exists in the Physics Department. Interaction between the two Departments is encouraged. Salaries are attractive. Applicants should submit their resume, including three references and a listing of research and instructional experience, to Professor Christopher N.K. Mooers, Chairman, Department of Oceanography, Naval Postgraduate School, Monterey, CA 93943 by 1 February 1985. For additional information telephone Professor Edward B. Thornton at 408-646-2847.

The Naval Postgraduate School is an equal opportunity/affirmative action employer.

Faculty Positions in Oceanography/Florida Institute of Technology, Jensen Beach Campus. The Department of Engineering Sciences and Oceanographic Technology invites applications for faculty positions in oceanography, specializing in either (1) chemical oceanography or (2) ocean engineering. Primary duties are classroom, laboratory, and some shipboard teaching, although research is also encouraged.

The chemical oceanography position includes teaching ocean chemistry and seawater analysis classes and laboratories, primary responsibility for operation and maintenance of the Seawater Analysis Laboratory, and teaching related oceanography courses. Laboratory experience, particularly analysis of seawater and water quality using wet chemistry, atomic absorption, and gas chromatography, is required.

The ocean engineering position includes teaching oceanographic and related engineering courses, with emphasis on applications to marine systems, including oceanographic data acquisition and engineering design and analysis.

Minimum requirements for the above positions include a masters degree in the subject field. Teaching experience is desired, and salary is commensurate with qualifications. Positions are available starting as early as January 1985, so interested applicants should submit (1) a curriculum vita, (2) official college transcripts, and (3) three letters of recommendation as soon as possible to:

Professor Lee E. Harris, P.E.
Engineering Sciences Department Head
Florida Institute of Technology
1707 N.E. Indian River Drive
Jensen Beach, FL 33457
An EEO/AA Employer.

Postdoctoral Research Appointments/UCLA. Applications are invited for several anticipated appointments on the Research staff at the Space Science Group of the Institute of Geophysics and Planetary Physics, University of California, Los Angeles. The successful applicants will be expected to devote a substantial fraction of time to research and project activities in one or more of the following areas: physics of the Jovian magnetosphere including scientific investigations and data system development; physics of the terrestrial magnetosphere, including analysis of ISEE and AMPTE data; solar wind-planetary studies including analysis of Pioneer Venus data.

Applicants for these positions should possess the Ph.D. degree in a relevant area of physics, astronomy, or planetary sciences. Some experience with data analysis is desirable but not essential.

A resume, copies of no more than three publications or preprints and the names of three references should be sent to: Dr. Christopher T. Russell, Dr. Margaret G. Kivelson or Dr. Robert L. McPherron, Institute of Geophysics & Planetary Physics, UCLA, Los Angeles, CA 90024.

The University of California encourages applications from qualified women and minorities.

Isotope Geochemistry/Mass Spectrometry. McMaster University invites applications for a tenure track position at the Assistant or Junior Associate Professor level. The candidate should have completed the Ph.D. degree and preferably have postgraduate research experience. A strong background in the theory and practical use of mass spectrometers is essential. Familiarity with software, including interfacing, would be a definite asset. At McMaster, there are a number of mass spectrometers for the analysis of both stable and radiogenic isotopes. Recent acquisitions include an ICP quadrupole/mass spectrometer and a 5-collector solid source mass spectrometer. The successful candidate will be expected to pursue an independent research program, as well as interact strongly with an active group of geochemists at McMaster.

The closing date for applications is March 15, 1985.

In accordance with Canadian immigration requirements, priority will be given to Canadian citizens and permanent residents of Canada.

Send resume, transcripts and the names of three referees to:

Dr. R.H. McNutt, Chairman
Department of Geology
McMaster University
Hamilton, Ontario L8S 4M1

Geochemistry. The University of California, Davis will fill a permanent, tenure track, faculty position at the assistant professor level beginning Fall, 1985. Candidates having interests in isotope geochemistry and/or the geochemistry of economic deposits are especially encouraged to apply but other specialties in geochemistry will be considered. A PhD degree is required. Responsibilities include teaching at the undergraduate and graduate levels and research in geochemistry.

Applicants should submit complete vita, a statement of research and teaching interests and the names of three referees. Deadline for application is January 15, 1985. Vitae and applications should be directed to: Dr. Howard W. Day, Department of Geology, University of California, Davis, CA 95616.

The University of California is an equal opportunity/affirmative action employer.

Caltech Research Faculty Position. The California Institute of Technology invites applications for a postdoctoral position in experimental cosmic ray studies. The appointment will normally be for one year with likely renewal for a second and possibly a third year. The research will involve the analysis of cosmic ray and energetic particle data acquired by instruments on the Voyager, IMP, and ISEE-3 spacecraft and participation in the Voyager 2 encounter with Uranus in January 1986. Applications should be addressed to Professor E.C. Stone, 220-47 Downs Lab, Caltech, Pasadena, CA 91125. Applicants should submit their vitae, list of publications and description of research interests, and should arrange for the sending of three letters of recommendation.

Caltech is an affirmative action/equal opportunity employer. Women/minorities are encouraged to apply.

The University of Minnesota: Structural Geology/Tectonics. The University of Minnesota Geology and Geophysics invites applications for a new, tenure track position in structural geology and tectonics. Candidates will be expected to carry out an active research program in their field of interest and to assume teaching and advising responsibilities at the undergraduate and graduate levels. A Ph.D. is required. The position will be available fall 1985. Application deadline is February 15, 1985. Applicants should send curriculum vitae, list of publications, statement of research interests, and names of at least three references to Peter Hudleston, Chairman, Department of Geology and Geophysics, University of Minnesota, Minneapolis, Minnesota 55455.

The University of Minnesota is an equal opportunity educator and employer and specifically invites and encourages applications from women and minorities.

Faculty Position in Dynamical Oceanography. An academic position (tenure track) is presently available at the assistant or junior associate professor level in the Department of Oceanography, Naval Postgraduate School. An ocean dynamicist experienced in the modeling of mesoscale ocean processes is preferred. The candidate should be competent in the analysis of pertinent observations, and be able to teach a variety of graduate courses in physical oceanography. The applicant should have an earned Ph.D. with an academic background in physical oceanography or a closely related field. Desirable attributes include field experimental interest and experience at sea and/or a strong interest in satellite remote sensing of the ocean. The successful candidate will be expected to teach one or two quarters per year, conduct sponsored research, and provide thesis supervision. The access to computer, data archive, and research vessel facilities is excellent. Basic and applied research opportunities are abundant. Interactions with ocean dynamicists in the Meteorology Department are also possible. Salaries are attractive and are determined by the qualifications of the successful candidate. By 1 February 1985, send a curriculum vitae, the names and addresses of three references, and a statement of research and instructional interests to:

Professor Christopher N.K. Mooers, Chairman
Department of Oceanography
Naval Postgraduate School
Monterey, CA 93943

Applicants who are currently doctoral candidates will be considered for appointment as instructors, with a tenure track appointment upon completion of the degree. For additional information, telephone Professor Edward B. Thornton at 408-646-2847.

The Naval Postgraduate School is an equal opportunity/affirmative action employer.

Geosciences. Applications are invited for two faculty positions with responsibilities, respectively, in 1) petrology and mineralogy and 2) historical and physical geology. Appointments will be full time assistant professor or instructor level, non-tenure track, for 2 or 3 years beginning September 1985. Send letter, resume, transcripts, and three recommendations by February 1, 1985 to John B. Brady, Chair, Department of Geology, Smith College, Northampton, MA 01060.

Smith College is an equal opportunity employer.

SERVICES, SUPPLIES, COURSES, AND ANNOUNCEMENTS

Availability of Request for Cooperative Agreement Applications: RFA# 1000-A. Acid Deposition Monitoring Support for Effects Research/U.S. Environmental Protection Agency. Application Receipt Date: January 18, 1985.

The U.S. Environmental Protection Agency (E.P.A.), under the National Acid Precipitation Assessment Program (NAPAP), is announcing the availability of funds for Fiscal Year 1985 for awarding a cooperative agreement(s) to support acid deposition monitoring stations to enhance the results of acid deposition effects studies. The research areas of primary interest involve studies of acid deposition including ambient air pollution mechanisms and rates of damage to forest ecosystems, calibrated watersheds and building materials. EPA has approximately one million dollars available to award cooperative agreement(s) to support this project. Support for this program may be for a period extending up to five years. In order to receive a copy of the RFA and further information contact:

Dr. Clarice E. Gaylord
Research Grants Staff
Office of Research & Development
U.S. Environmental Protection Agency
401 M Street, SW
Washington, D.C. 20460
Telephone 202-382-7473

Electron Probe. Fully operative manual three-channel ARL-EMX instrument with TN-2000 analyzer. Electronics partly updated; one spectrometer rebuilt. Available now. Contact: D. Smith, Department of Geology, University of Texas, Austin, TX 78713.

Meetings

Announcements

Meteorology, Oceanography, and Hydrology

January 7–11, 1985 International Conference on Interactive Information and Processing Systems for Meteorology, Oceanography, and Hydrology, Los Angeles, Calif. Sponsor: American Meteorological Society. (Nancy Schiffman, SES Inc., PO Box 2697, Springfield, VA 22152; tel.: 703-644-9472.)

This conference is designed for professionals from government and industry from both the U.S. and world community who supply and use information systems, technology, and data in meteorology, oceanography, and hydrology. The primary focus will be information and processing systems for data applications. Topics include, among others, interactive systems for centers, forecast and warning offices, television stations, and research; systems, technology, and applications for developing countries; display and computer systems, architecture, and technology; photogrammetry, cartographics, and mapping technologies; human factors and engineering in design, operations, and presentations; and management, training, and coordination. A field trip to the California Institute of Technology's Jet Propulsion Laboratory is scheduled.

Seismology

April 15–17, 1985 80th Annual Meeting of the Seismological Society of America, Austin, Tex. (2620 Telegraph Ave., Berkeley, CA 94704; tel.: 415-848-0954.)

The deadline for the submission of abstracts is January 15, 1985.

Papers reporting original research in seismology and earthquake engineering are invited. Only one paper per speaker will be accepted (exceptions may be made for speakers who have been invited to speak on specific subjects). This meeting will feature six special symposia with invited papers on topics of timely and general interest. Contributed papers will be added to these symposia as appropriate. Contributors who desire their papers to be considered for the special symposia should note this on their abstract forms. Symposia topics include the Meers Fault, advances in seismic data processing, seismicity induced by fluid injection and withdrawal, and deep earthquakes and deep mantle structure, among others.

Hydrology Days '85 Update

April 16–18, 1985 AGU Fifth Annual Front Range Branch Hydrology Days, Fort Collins, Colo. (H. J. Morel-Seytoux, Department of Civil Engineering, Colorado State Univ., Fort Collins, CO 80523; tel.: 303-491-5448/8549.)

The invited speakers at the Hydrology Days include

- Takashi Asano, California Department of Water Resources: "Groundwater Recharge With Reclaimed Municipal Wastewater"
- Peter K. Kitanidis, Department of Civil and Mineral Engineering, University of Minnesota: "Unbiased Minimum Variance Filtering of Hydrologic Systems in the Presence of Unknown Parameters or Inputs"
- P. Christopher Milly, Department of Civil Engineering, Princeton University: "Evaporation From Soils"
- Rien Van Genuchten, U.S. Salinity Laboratory, Riverside, California: "Solute Transport Processes in Structured Soils"

A complete announcement for this meeting has already been published in *Eos*, July 24, 1984, p. 453.

History of Hydrology

May 27–31, 1985 History of Hydrology, Baltimore, Md. AGU. (Simon Ince, Department of Hydrology and Water Resources, Univ. of Arizona, Tucson, AZ 85721; tel.: 602-621-5082.)

The deadline for the submission of abstracts is February 18, 1985.

This symposium, organized by the AGU History and Heritage of Hydrology Committee, will be part of the AGU Spring Meeting. No specific topics are prescribed for papers, but general areas of interest may include the lives and contributions of individual researchers, the evolution of concepts, the growth of hydrology as a specific discipline, the development of theoretical and experimental techniques and methodologies, and the historical interrelationships between hydrology and water resources.

Snow Conference

June 6–7, 1985 42nd Eastern Snow Conference, Montreal, Canada. (Hilda J. Snelling, Program Chairman ESC, Chief, Engineering Meteorology Section, USAFETAC, Scott AFB, IL 62225.)

The deadline for the submission of abstracts is January 31, 1985.

Papers are solicited on any appropriate topic; past topics have included remote sensing of snow, aspects of sea ice, snow measurement systems, biological roles of snow and ice, hydrologic aspects of snow, and snow loading, among others. Poster sessions will also be featured. In addition to the general sessions there will be special sessions on snow and ice research and applications in Quebec and on snow and ice hydrology. Student participation is encouraged. Students who wish to submit a paper to the an-

Meetings (cont. on p. 1216)

HORTON RESEARCH GRANT PROPOSALS SOUGHT

The American Geophysical Union is seeking proposals for the award of the 1985 Horton Research Grant. **The deadline is March 1, 1985.** The grant will be in support of a research project in hydrology and/or water resources by a Ph.D. candidate in an American institution of higher education. Proposals may be in hydrology (including its physical, chemical or biological aspects) or in the water resources policy sciences (including economics, systems analysis, sociology and law).

Selection will be made by a committee of AGU's Hydrology Section. The award in the amount of $7,500 will be made directly to the winner during the 1985 AGU Spring Meeting.

For a detailed description of the grant and a guide for proposers, write to:

Horton Research Grant
American Geophysical Union
2000 Florida Avenue, N.W.
Washington, DC 20009
202/462-6903

DEADLINE: MARCH 1, 1985

Meetings *(cont. from p. 1215)*

nual Eastern Snow Conference Student Paper Contest (with a prize of $100 and up to $350 in expenses to attend the conference) should contact Don Taylor, Chairman, Research Committee ESC, National Research Council Canada, M-20, Montreal Road, Ottawa, K1A 0R6, Canada.

Radiocarbon Conference

June 24–28, 1985 12th International Radiocarbon Conference, Trondheim, Norway. (12th International Radiocarbon Conference, Attn: Pat Ueland, Studies and Academic Administration, Norwegian Institute of Technology, N-7034 Trondheim—NTH, Norway.)

The deadline for the submission of abstracts is January 1, 1985.

The aim of the conference is to bring together researchers from various fields with a common interest in ^{14}C. Among the major topics for discussion will be the possible causes of ^{14}C variations in the past, the contribution of ^{14}C to knowledge of the carbon cycle in nature, the latest developments in accelerator mass spectrometry and mini gas counters for dating very small samples, the possible sources of error that influence various sample materials, and ways of handling the great number of dates in data bases. There will also be several overview talks on various disciplines.

Crustal Extension

October 10–12, 1985 Conference on Heat and Detachment in Crustal Extension on Continents and Planets, Sedona, Ariz. Sponsors: Lunar and Planetary Institute, USGS, GSA. (Pam Jones, LPI Projects Office, Lunar and Planetary Institute, 3303 NASA Road 1, Houston, TX 77058; tel.: 713-486-2150.)

The abstract deadline is April 29, 1985.

The conference is aimed at exploring the role of thermal and mechanical crustal decoupling in controlling the tectonic style of extension on terrestrial continents and solar planets, using field and laboratory data as well as modeling considerations.

Attendance is limited to 75 people; potential participants should contact LPI as soon as possible for inclusion on the mailing list.

Meeting Report

Crustal Observations Through Drilling

The use of the drill to probe the earth's crust, driven by primarily economic incentives, has come a long way since the first oil well at Titusville, Penn., began producing from a depth of 21 m in 1859. Wells have now been drilled to depths of over 12 km (in the Kola Peninsula of the Soviet Union), in rocks where the pressure of pore fluid equals the weight of the entire overburden, in rocks at temperatures exceeding 400°C, and even in molten basalt in Hawaiian pit craters flooded by recent lava flows. To compensate for the hostility of such environmental extremes, drilling for resources has become one of the most robust of modern technologies.

In the late 1960's, when the ocean floors were hypothesized to have originated at the midocean ridges and to be consumed at the deep trenches, drilling proved to be the ultimate test of the revolutionary theory of plate tectonics. Now, earth scientists, confronted by problems of the evolution of the continents and physicochemical processes currently active in shaping them, have begun using drilling as one of the most valuable of experimental tools in understanding the continental lithosphere.

The International Symposium on Observation of the Continental Crust Through Drilling, held May 20–25, 1984, in Tarrytown, N.Y., was organized by the U.S. Department of Energy (DOE), the National Science Foundation (NSF), and the U.S. Geological Survey (USGS) with several questions in mind. First, what are the major scientific problems that require drilling to provide the necessary observations and what results have already been achieved? Second, what are the current possibilities and limitations of drilling and logging? Finally, what have other nations accomplished, and how do we go about constructing a national program that most efficiently uses the resources and expertise available from the U.S. oil industry?

The sessions occupied 4½ days, beginning with a review of national scientific drilling programs and concluding with a session involving participants from the oil industry who discussed the advantages of drilling scientific holes and the role of industrial scientists in a national scientific drilling program. The symposium organizing committee consisted of Barry Raleigh (chairman), Lamont-Doherty Geological Observatory of Columbia University; Robert S. Andrews, National Research Council; John P. Hermance, Brown University; William C. Luth, Sandia National Laboratories; Edward Schreiber, Queens College of the City University of New York; Francis G. Stehli, University of Oklahoma; Samuel G. Varnado, NL Sperry-Sun; Helmut Vidal, Bayerisches Geologisches Landesamt; and Mark D. Zoback, USGS.

There are currently efforts in West Germany, France, Belgium, Japan, the United Kingdom, Canada, Austria, and Sweden involving drilling for scientific purposes. Although for some countries the incentive may ultimately be economic in motive (e.g., coal in Belgium, oil in Austria), most of these programs are designed to extract information on the structure, composition, and physical and chemical properties of the crust. The Soviet Union operates the most ambitious program of scientific drilling, having reached 12 km depth in ancient crystalline basement and 8.5 km into a sedimentary basin. Other deep holes are being planned while the first ones are still being drilled.

Despite the differences in objectives, both planned efforts and active programs in all the countries have in common a sequence of events beginning with selection of scientific priorities. Geophysical and geological surveys designed to elucidate the geologic and thermal structure, leading ultimately to the choice of a drilling site, are followed by some relatively shallow drill holes of 1–2 km. Drilling is the culmination of a sequence of events leading to a geological evaluation of the most promising site based on criteria, which, in addition to the above, include a well-designed drilling plan.

The symposium was organized at a fortuitous time. It was clear that scientists worldwide have come to a remarkably congruent decision, quite independently, that penetrating the continents by direct sampling through drilling is the necessary next step to understanding the evolution of the earth.

The conferees pointed out some of the most interesting problems for which drilling could provide the answers. Scientists are now developing models of hydrothermal circulation and ore deposition that can be tested with information obtainable only from depth in active or fossil systems (R. Fournier, USGS; Jim Eidel, Coastal Mining). Convective circulation driven by heat derived from magmatic intrusions is a vast and fascinating chemical processing system. The development of the economically interesting by-products, bodies of ore, and geothermal resources depend on the form that convection cells take, which in turn depends on such issues as the salinity of brines, fracture permeability, and the storage capacity of the rock matrix. Drilling wells of moderate depth in a few active silicic volcanic centers, such as the ones located at Yellowstone, the Imperial Valley, Long Valley, or the Valles Caldera, would provide extraordinarily useful information concerning the chemistry and the thermal and mass transfer mechanisms in convective hydrothermal systems.

John Rundle of Sandia and Alan Ryall of the University of Nevada gave an excellent example of the use of data from surface measurements obtained from seismic arrays and from geodetic leveling and trilateration at Long Valley, Calif., for modeling the location and motion of magma intrusion into the upper crust. Even a few holes to rather modest depth would serve to fix some of the parameters, such as stress, needed to constrain the models.

Bodies of ore, now parts of fossil hydrothermal systems, may yield some of the data fundamental to modeling such systems, provided that drilling to the roots of the hydrothermal convection cells can be conducted. Studies by Craig Bethke and others at the USGS of the Creede epithermal Ag-Pb-Zn, Cu ore district in Colorado have shown that the ores were deposited at the contact of surface waters with an underlying hot convecting brine. However, the source of heat, salinity of the fluid, and the concentration of sulfur and metals have not been investigated, and scientific drilling is required to reach the root zone in order to study these factors.

The deep structure of the continents, particularly in the mobile belts, has been investigated sufficiently in certain areas so that drilling is now needed to test the geological reconstructions. Several targets seem to be most attractive for drilling. The southern Appalachians, described by Robert Hatcher of the University of South Carolina, are the possible locus of at least two cycles of continental rifting and collision, which appear to have expression in seismic sections of very extensive, low-angle thrusting of crystalline rocks over Paleozoic sedimentary and metasedimentary rocks. To penetrate through to the autochthonous rocks requires drilling, perhaps to depths of 10 km. However, a drilling expert at the conference, Frank Schuh (ARCO), was not daunted by the depth, given the rather benign environment expected. Other seismic reflection profiles in the western United States indicate low-angle thrusting, perhaps currently active, where drilling might lead to measurements of the properties which make such paradoxical structures possible. A word of caution about the interpretation of strong low-angle reflectors was sounded by George Thompson of Stanford University. A deep hole drilled for oil exploration through such a reflector in southern Arizona found a zone of apparent movement within granite both above and below the presumed overthrust.

Mark Zoback of the USGS (now at Stanford University) emphasized the paradoxical contrast between geophysical observations which suggest that earthquakes occur at low shear stress while the laboratory estimates from rock mechanic measurements suggest that much higher stresses should be required. Zoback has accumulated measurements of stress at less than 1 km depth which agree with the laboratory data but do not resolve the problem. The nature of the preearthquake failure process is poorly understood because of the absence of direct observation from hypocentral depths of the observations of stress, pore fluid pressure, permeability, etc., critical to understanding the phenomenon.

In summary, the scientific objectives for drilling fall into two general categories. The first is that of reconstructing the petrologic and tectonic history of the continental crust. Results already obtained from basement samples obtained by M. E. Bickford and W. R. Van Schmus of the University of Kansas from oil well drilling are beginning to extend our knowledge of the age and distribution of igneous activity of the ancient basement of the midcontinent. Lee Silver (Caltech) finds correlative Proterozoic ages of basement in California. However, better areal distribution than that currently available is needed. The oldest rocks of the continent exposed in Minnesota and Canada are also desirable targets for deep drilling to sample the deepest and oldest regions of the crust.

The second general category is the investigation of active processes, such as faulting, volcanism, rifting, metamorphism, and ore deposition. The array of physicochemical parameters needed to test existing models and the exploration necessary even to construct adequate models of these processes is not measurable from the surface. Inferences as to temperature, elastic properties, density, and electrical conductivity at depth are model dependent, and surface measurements lack the required resolution beyond the uppermost few kilometers of depth. It must be emphasized that the state of stress, the hydraulic diffusivity and storage capacity, the thermal diffusivity, pore fluid chemistry and pressure, the bulk, chemistry and phase composition of the rocks, their isotopic constitution and age, the state of fracturing, and the details of the elastic properties, density, temperature, and electromagnetic properties can only be measured in situ at depth and require drilling. It is a triumph of the earth sciences that so much has been inferred about the crust from the meager surface information available.

A substantial part of the symposium dealt with the issues of how to measure the relevant parameters down hole, particularly where high temperatures render conventional technology unsuitable. Logging technology is quite advanced, although the requirements of a scientific drilling program are such that coring is required extensively. In deeper holes in hard rock, however, coring may be difficult and result in low recovery. Research on drilling, coring, and logging tools for hard rock scientific drilling is underway in industrial and government laboratories. High-temperature (>300°C) logging is also a major research and development effort of the DOE. Where core recovery is incomplete because of technical difficulty or high cost, there is reasonable expectation that logging methods can be used to fill in the gaps in information. Measurement of stress, fracture density, fluid pressure, and permeability have been conducted in boreholes at moderate depths but become much more difficult in high-temperature wells. The Los Alamos group that is interested in recovery of geothermal power from hot dry rock reported on significant improvements in this technology for higher temperature regimes.

Gary Ohlsen and Jeff Daniels of the USGS, Roger Anderson of Lamont-Doherty, and Mark Mathews of Los Alamos made a strong case that most of the relevant physical properties can be measured through in situ measurements as well as or better than from core. New techniques are being developed to permit more complete mineralogic and geochemical information to be determined, although coring or sampling is still essential to allow for such critical measurements as bulk composition, radiometric ages, isotopic constitution, mineralogy, and also detailed geological information.

A considerable amount of scientific drilling has been under way in the United States, Iceland, Belgium, and of course, in the deep oceans through the Joint Oceanographic Institutions for Deep Earth Sampling (JOIDES) deep sea drilling program. Although in the United States a few holes of opportunity, drilled for other purposes, have made possible relatively inexpensive add-on experimentation by groups of investigators, such holes cannot be exploited fully because of problems of timing, less than optimum location or depth, and other impediments. Geothermal drilling in Iceland, reported upon by Ingvar Fridleifsson, has provided a scientific bonanza because of close coordination between the scientists and those drilling the holes. Similarly, in the program to test the feasibility of extracting thermal energy from hot dry rock at the Los Alamos National Laboratory, drilling has been closely tied to the needs of the scientists. John Rowley of Los Alamos described the remarkably successful efforts to drill and conduct downhole measurements in the deep and hostile environment of the hot Fenton Hill granite.

On Cyprus, where a slab of oceanic crust and upper mantle (ophiolite sequence) of island arc affinity has been thrust onto the island, drilling has been conducted by a multinational group with the goal of providing a complete section through the ophiolite. Paul Robinson of Dalhousie University made the important point that the nearly complete core recovery made possible a detailed description of the structure, stratigraphy, and petrologic variability that would not have been possible from any amount of field work alone.

Ross Heath of the University of Washington reviewed the remarkably successful Deep Sea Drilling Program. Recovery and preservation of the core has been one of the principal reasons for the program's success. Paleoceanography, for example, is a new scientific offshoot of the drilling program which would have been impossible without nearly complete core recovery.

Sedimentary basins have been extensively drilled for commercial ventures, and consequently, the most subsurface data is available for this major structural feature of the continent. Nonetheless, commercial wells have been drilled with neither the minimum amount of core recovery required for scientific investigations, nor the full array of measurements downhole to constrain theoretical basin models. Downhole gravity, temperature, and thermal conductivity would be most useful in certain basins. At the close of the meeting, an open discussion on the interaction of oil industry scientists and engineers with academic and government scientists in a scientific drilling program led to several important points, including especially (1) the importance of obtaining as much information as possible from industry and other sources before drilling and (2) that the thorough design of a hole, particularly a deep well, is a costly but necessary preliminary to drilling. The oil industry participants agreed that a well-planned scientific drilling program would have great value.

The consensus that a national scientific drilling program is a timely and critical next step for the earth sciences existed before the symposium. The symposium, in bringing together those who have already gained much experience in drilling, with the scientists who need the data from the crust's third dimension, was the first in what must be a series of dialogues. The existing technology of surface exploration drilling and downhole measurements can be brought to bear on several extremely important scientific problems without much additional engineering research and development. Where temperatures are moderate (~250°C) and the rocks encountered are reasonably stable mechanically, moderate to deep holes can provide fundamentally important observations on the evolution of the crust and the processes that have shaped the continents. There are, however, needs for new technological advances in coring, logging, and drilling in more hostile environments. The momentum of the DOE national laboratories in such technological development needs to be sustained if we are to address the important scientific problems of the nature of active hydrothermal systems, metamorphism and ore deposition. With the evident willing cooperation of the petroleum industry and academic scientists, the DOE, NSF, and USGS, a national program of continental scientific drilling appears to be moving forward.

This meeting report was contributed by Barry Raleigh, *Lamont-Doherty Geological Observatory of Columbia University, New York.*

Geophysical Year

A date at the end of an entry indicates the issue of *Eos* in which a full meeting announcement was run.

A list of abbreviations used in the Geophysical Year calendar appears at the end of the calendar.

Future AGU Meetings:

Fall Meetings

Dec. 9–13, 1985, San Francisco, California *(Abstracts due mid-September 1985)*

Dec. 8–12, 1986, San Francisco, California

Spring Meetings

May 27–31, 1985, Baltimore, Maryland *(Abstracts due early March 1985)*

May 19–23, 1986, Baltimore, Maryland

Regional Meetings

Front Range Branch Hydrology Days
April 16–18, 1985, Fort Collins, Colorado *(Abstracts due January 15, 1985 for professional hydrologists; February 15, 1985 for students)*

Chapman Conferences

Solar Wind-Magnetosphere Coupling
February 12–15, 1985, Pasadena, California

Ion Acceleration in the Ionosphere and Magnetosphere, June 3–7, 1985, Boston, Massachusetts.

Magnetotail Physics, October 28–31, 1985, Laurel, Maryland.

1984

Dec. 16–21 **International Chemical Congress** of Pacific Basin Societies, Honolulu, Hawaii. Sponsors: ACS, Chemical Institute of Canada, Chemical Society of Japan. (PAC CHEM '84, Meetings and Divisional Activities Dept., ACS, 1155 16th St., N. W., Washington, DC 20036; tel.: 202-872-4396; PAC CHEM '84, Chemical Institute of Canada, 151 Slater St., Suite 906, Ottawa, Ontario K1P 5H3, Canada; tel.: 613-233-5623; PAC CHEM '84, Chemical Society of Japan, 1–5, Kanda-Surugadai, Chiyoda-ku, Tokyo 101, Japan; tel.: 03-292-6161.) (Sept. 13, 1983.)

Dec. 17–21 **Tectonic Studies Group** 15th Annual General Meeting, Swansea, U.K. Sponsor: University College of Swansea. (Richard Lisle, Dept. of Geology, University College, Swansea SA2 8PP, United Kingdom.)

Dec. 28–31 Fourth International Conference on **Applied Numerical Modeling**, Tainan, Taiwan. (S. Y. Wang, School of Engineering, Univ. of Mississippi, University, MS 38677; tel.: 601-232-7219.)

1985

Jan. 7–11 International Conference on Interactive Information and Processing Systems for **Meteorology, Oceanography, and Hydrology**, Los Angeles, Calif. Sponsor: American Meteorological Society. (Nancy Schiffman, SES Inc., PO Box 2697, Springfield, VA 22152; tel.: 703-644-9472.)

Jan. 7–12 17th International Congress on **Hydrogeology of Rocks of Low Permeability**, Tucson, Ariz. Sponsors: International Assoc. of Hydrogeologists, AGU. (E. S. Simpson, Dept. of Hydrology and Water Resources, College of Engineering, Univ. of Arizona, Tucson, AZ 85721.)

Jan. 7–11 International Conference on Interactive Information and Processing Systems for **Meteorology, Oceanography, and Hydrology**, Los Angeles, Calif. Sponsor: AMS. (G. Stanley Doore, Office of the Federal Coordinator, 11426 Rockville Pike, Suite 300, Rockville, MD 20852; tel.: 301-443-8704.) (Aug. 14, 1984.)

February International Symposium on **Recent Crustal Movement**, Maracaibo, Venezuela. Sponsor: IAG. (Heinz Henneberg, Apartado 6, Maracaibo, Venezuela; telex: 61263 CAMER VC.)

Feb. 4–6 National Conference on **Water Resources Research**, Chevy Chase, Md. Sponsor: Universities Council on Water Resources. (William L. Powers, Executive Secretary, Universities Council on Water Resources, 310 Agricultural Hall, University of Nebraska, Lincoln, NE 68583-0711; tel.: 402-472-3305.)

Feb. 6–7 USGS Forum on Research in **Mineral Resources**, Denver, Colo. (William R. Miller, USGS, P. O. Box 25046, Mail Stop 912, Denver Federal Center, Denver, CO 80225; tel.: 303-236-5558.)

Feb. 10–15 **Australian Physical Oceanography** Conference, Hobart, Tasmania. Convenor: Eric J. Lindstrom. (Eric Lindstrom, CSIRO Marine Laboratories, GPO Box 1538, Hobart, Tasmania, Australia 7001.) (Sept. 4, 1984.)

Feb. 12–15 Chapman Conference on **Solar Wind-Magnetosphere Coupling**, Pasadena, Calif. (AGU, 2000 Florida Ave., N. W., Washington, DC 20009.)

Feb. 17–20 Second Symposium on **Industrial Resource Management**, Philadelphia, Penn. Sponsors: University of Pennsylvania, *Journal of Resource Management and Technology*. (Iraj Zandi, 220 S. 33rd St., Towne Building/D3, Univ. of Pennsylvania, Philadelphia, PA 19104; tel.: 215-898-8368.)

Feb. 20–22 Workshop on **ODP Drilling** in the Northeast Pacific, Seattle, Wash. Sponsor: International Northeast Pacific Activities Consortium (INPAC). (Paul Johnson, School of Oceanography WB-10, Univ. of Washington, Seattle, WA 98195; tel.: 206-543-8474.)

Feb. 23–24 International **Erosion Control** Association 16th Annual Conference and Trade Show, San Francisco, Calif. (International Erosion Control Assoc., P. O. Box 807, Freedom, CA 95019.)

Feb. 26–27 **Solar Photovoltaic Systems**: Today's Technology and Applications, Honolulu, Hawaii. Sponsor: Department of Engineering and Applied Science, University of Wisconsin–Extension. (Don Schramm or Linda Hook, Department of Engineering and Applied Science, Univ. of Wisconsin–Extension, 432 North Lake St., Madison, WI 53706; tel.: 608-263-7757.)

Feb. 26–28 Second **Hydrology Symposium on Surface Coal Mining** in the Northern Great Plains, Gillette, Wyo. Sponsor: Gillette Area Groundwater Monitoring Organization. (Ron Landers, Carter Mining Company, P. O. Box 3007, Gillette, WY 82716; tel.: 307-682-8881.) (July 24, 1984.)

March 4–9 **Extraterrestrial Physics** and Symposium on Active Experiments in Space, Munich, Federal Republic of Germany. Sponsors: German Physical Society, German Geophysical Society, European Geophysical Society. (E. Keppler, Max-Planck-Institut für Aeronomie, Postfach 20, D-3411 Katlenburg-Lindau 3, Federal Republic of Germany or H. Soffel, Institut für Allgemaine und Angewandte Geophysik der Universität, Theresianstrasse 41, D-8000, München 2, Federal Republic of Germany.)

March 10–15 American Society of **Photogrammetry** and American Congress on **Surveying and Mapping** National Meeting, Washington, D. C. (Willard A. Rancis, 4415 Jensen Pl., Fairfax, VA 22032; tel.: 703-425-8790.)

March 11–15 16th **Lunar and Planetary Science Conference**, Houston, Tex. Sponsors: Lunar and Planetary Institute, AGU, NASA Johnson Space Center, Division for Planetary Sciences of the American Astronomical Society, GSA, Meteoritical Society. (Pamela Jones, Conference Administrator, Lunar and Planetary Institute, 3303 NASA Road 1, Houston, TX 77058; tel.: 713-486-2150.)

March 18–21 International Conference on **Integral Methods in Science and Engineering**, Arlington, Tex. Sponsor: Univ. of Texas at Arlington. (Fred R. Payne, A.E. Dept., Univ. of Texas-Arlington, 76019; tel.: 817-273-2074.) (July 24, 1984.)

April 1–3 Workshop on the Correction of **Precipitation Measurements**, Zürich. Organizers: Swiss Federal Institute of Technology, International Association of Hydrological Sciences, World Meteorological Organization. (Boris Sevruk, Hydrology Section, Department of Geography ETH, Winterturerstrasse 190, 8057 Zürich, Switzerland.) (Nov. 27, 1984)

April 1–4 **European Union of Geosciences** Biennial Meeting, Strasbourg, France. (Organizing Committee, Dept. of Earth Sciences, Univ. of Cambridge, Downing St., Cambridge CB2 3EQ, U.K.)

April 14–19 GSA Penrose Conference on **Geomorphic and Stratigraphic Indicators of Neogene-Quaternary Climatic Change** in Arid and Semiarid Environments, Lake Havasu City, Ariz. Conveners: John Dohrenwend, USGS; Steve Wells and Les McFadden, Univ. of New Mexico. (John Dohrenwend, USGS, Mail Stop 941, 345 Middlefield Rd., Menlo Park, CA 94025.)

April 15–17 80th Annual Meeting of the **Seismological Society of America**, Austin, Tex. (2620 Telegraph Ave., Berkeley, CA 94704; tel.: 415-848-0954.)

April 15–19 First International Symposium on **Precise Positioning with the Global Positioning System**, Rockville, Md. Sponsors: IAG, IUGG, Defense Mapping Agency, NOAA. (Positioning with GPS-1985, White Flint Mall, Post Office Box 2095, Kensington, MD 20895.)

April 15–19 Second International Symposium on **Analytical Chemistry** in the Exploration, Mining, and Processing of Materials, Pretoria, South Africa. Sponsor: International Union of Pure and Applied Chemistry. (The Symposium Secretariat S.328, CSIR, Box 395, Pretoria, 0001 South Africa.)

April 16–18 Fifth Annual **AGU Front Range Branch Hydrology Days**, Fort Collins, Colo. (H. J. Morel-Seytoux, Dept. of Civil Engineering, Colorado State Univ., Fort Collins, CO 80523; tel.: 303-491-5448 or 8540.) (July 24, 1984.)

April 18–20 **Continental Extensional Tectonics**, Durham, England. Sponsor: Geological Society. (J. F. Dewey, Dept. of Geological Sciences, Durham University, Durham DH1 3LE, England.)

April 19 Lithoprobe Phase I, Vancouver Island, **Subduction and Accretion Processes**, Victoria, B. C., Canada. Sponsors: Geological Assoc. of Canada, Canadian Geophysical Union. (E. Irving, Pacific Geoscience Centre, Box 6000, Sidney, B. C. V8L 4B2, Canada, or R. Clowes, Geophysics and Astronomy, Univ. of British Columbia, Vancouver, B.C. V6T 1W5, Canada.)

April 21–26 Third International Symposium on the **North American Vertical Datum**, Rockville, Md. Sponsors: AGU, IAG, NOAA, National Geodetic Survey. (Gary M. Young, Asst. Director, NAVD Symposium 85, White Flint Mall, P. O. Box 2065, Kensington, MD 20895; tel.: 301-443-8567.)

April 25–26 Seventh Annual Geodynamics Research Symposium on **Intraplate Deformation**: Characteristics, Processes, and Causes, College Station, Tex. Sponsors: Texas A&M University Geodynamics Research Program, Geodynamics Program Office of NASA, Inter-union Commission on the Lithosphere. (Brann Johnson, Department of Geophysics and Geodynamics Research Program, Texas A&M Univ., College Station, TX 77843–3114; tel.: 409-845-8297.)

April 28–May 1 International Conference on **Arctic Water Pollution Research**: Applications of Science and Technology, Yellowknife, Northwest Territories, Canada. Organizer: Canadian National Committee, International Assoc. on Water Pollution Research and Control. (K. Charbonneau, National Research Council of Canada, Montreal Road Laboratories, Ottawa K1A 0R6, Canada; tel.: 613-993-9009.) (July 10, 1984.)

April 30–May 1 Symposium on **Watershed Management**, Denver, Colo. Sponsor: ASCE. (E. Bruce Jones, President, Resource Consultants, Inc. P. O. Box Q, Fort Collins, CO 80522.) (May 1, 1984.)

May Symposium on **Hydrothermal Alteration and Geothermal Brine Chemistry, Processing, and Mineral Recovery**, Palm Springs, Calif. Sponsor: Geothermal Resources Council. (Grace Mata, Geothermal Resources Council, P. O. Box 1350, Davis, CA 95617–1350; tel.: 916-758-2300.)

May 5–8 International Syposium on **Tropical Hydrology**, San Juan, Puerto Rico. Organizer: American Water Resources Association. (Ferdinand Quinones, U.S. Geological Survey, WRD, GPO Box 4424, San Juan, PR 00936; tel.: 809-783-4660.)(Oct. 16, 1984)

May 6–10 Symposium on **Vertical Motion in the Equatorial Upper Ocean and its Effects on Living Resources and the Atmosphere**, Paris, France. Sponsors: Scientific Committee on Oceanic Research, UNESCO. (David Halpern, NOAA PMEL, 7600 Sand Point Way, N. E., Seattle, WA 98115.)

May 6–11 Institute on **Lake Superior Geology**, Kenora, Canada. (C. E. Blackburn, ILSG Conference Chairman, Resident Geologist, Ministry of Natural Resources, 808 Robertson St., PO Box 5080, Kenora, Ont. P9N 3X9 Canada; tel.: 807-468-9841.)

May 7–10 Symposium on **Arctic Rifting** Styles: Structure, Calgary, Alberta, Canada. Sponsor: International Lithosphere Program. (John W. Pierce, Petro-Canada Resources, PO Box 2844, Calgary, Alberta T2P 3E3, Canada.)

May 7–10 CSEG-CGU National Convention—**Geophysics**: The Facts of Earth, Calgary, Canada. Sponsors: Canadian Society of Exploration Geophysicists, Canadian Geophysical Union. (Graham Millington, Canadian Superior Oil Co., 3 Calgary Pl., 335 4th Ave. SW, Calgary, Alberta T2P 0H9, Canada; tel.: 403-267-4883 or John Peirce, Petro-Canada, PO Box 2844, 150 6th Ave. SW, Calgary, Alberta T2P 3E3, Canada; tel.: 403-296-3915.)

May 13–17 17th International Liège Colloquium on Ocean Hydrodynamics: Dynamic **Biological Processes at Marine Physical Interfaces**, Liège, Belgium. (Jacques C. J. Nihoul, Modelenvironment, University of Liège, B5, Sart Tilman, B-4000, Liège, Belgium.)

May 13–18 Third **JECSS (Japan and East China Seas Study) Workshop**, Tsukuba Univ., Japan. Sponsors: Japan Marine Science and Technology Center, Oceanographical Society of Japan, Japanese-French Oceanographical Society. (Takashi Ichiye, Dept. of Oceanography, Texas A & M Univ., College Station, TX 77843.) (Oct. 30, 1984)

May 14–15 Workshop on **Geomagnetism**, Canberra, Australia. Sponsor: Specialist Group on Solid Earth Geophysics of the Geological Society of Australia. (C. E. Barton, Bureau of Mineral Resources, PO Box 378, Canberra, ACT 2601, Australia or F. E. M. Lilley, Research School of Earth Sciences, Australian National Univ., Canberra, ACT 2600, Australia.)

May 19–24 2nd U.S.-Dutch International Symposium: **Aerosols**, Williamsburg, Va. Organizer: U.S. Environmental Protection Agency. (Si Duk Lee, U.S. Coordinator, 2nd U.S. Dutch International Symposium: Aerosols, U.S. Environmental Protection Agency (MD-52), Research Triangle Park, NC 27711.)

May 27–31 **AGU Spring Meeting**, Baltimore, Md. (Meetings, AGU, 2000 Florida Ave., N. W., Washington, DC 20009.)

May 27–31 Density Distribution of the **Lithosphere**: Static and Dynamic Models, Zürich. Organizer: International Association of Geodesy. (J. Bartholomew, Institut für Geodäsie und Photogrammetrie, HPV G 53, ETH-Hönggerberg, 8093 Zürich, Switzerland.)

May 27–June 1 Fifth **International Coral Reef Congress**, Tahiti, French Polynesia. (Organizing Committee, Coral Reef Congress, B.P. 562 Papeete, Tahiti, French Polynesia.) (Oct. 30, 1984)

Summer Colloquium on Comparative Study of **Magnetospheric Systems**, France. (Dominique Le Quéau and Bent Mooller-Pedersen, DASOP, Observatoire de Meudon, F 92195, Meudon Principal Cedex, France; Telex: 200 590 CNET OBS.) (Aug. 9, 1983.)

June Second International Conference on **Soil Dynamics and Earthquake Engineering**, on board the Queen Elizabeth II. Sponsor: Computational Mechanics Institute. (C. A. Brebbia, Computational Mechanics Institute, Ashurst Lodge, Ashurst, Southampton SO4 2AA England.)

June 3–7 Symposium on Stochastic Approach to **Subsurface Flow**, Fontainebleau, France. Sponsors: GRECO Hydrogeology of the Centre National de la Recherche Scientifique, Paris School of Mines. (G. de Marsily, GRECO Hydrogeologie, Ecole des Mines de Paris, Centre d'Informatique Géologique, 35, rue Saint-Honoré, 77305 Fontainebleau Cédex, France; tel.: 6–422–48–21.) (Oct. 16, 1984)

June 3–7 **AGU Chapman Conference on Ion Acceleration in the Ionosphere and Magnetosphere**, Boston, Mass. (AGU Meetings, 2000 Florida Ave., N. W., Washington, DC 20009.)

June 4–7 International Conference on **Mafic Dyke Swarms**, Mississauga, Ontario, Canada. Sponsors: IUGS Commission on Tectonics, the International Lithosphere Programme, and the Geological Survey of Canada. (H. C. Halls, Erindale Campus, Univ. of Toronto, Mississauga, Ontario L5L 1C6, Canada; tel.: 416-828-5363.)

June 6–7 42nd Eastern **Snow** Conference, Montreal, Canada. (Hilda J. Snelling, Program Chairman ESC, Chief, Engineering Meteorology Section, USAFETAC, Scott AFB, IL 62225.)

June 8–12 Third International Conference on **Toxic Dinoflagellates**, St. Andrews, New Brunswick, Canada. (Alan W. White, Biological Station, Department of Fisheries and Oceans, St. Andrews, New Brunswick, Canada E0G2X0.)

June 9–15 **IWRA** Fifth World Congress, Brussels, Belgium. (Fifth World Congress on Water Resources, Brussels International Conference Centre, Parc des Expositions, Tentoonstellingspark, B-1020 Brussels, Belgium; tel.: 32–2–478–48–60; telex: 23–643.) (Aug. 30, 1983.)

June 9–16 52nd Session of the Permanent Committee of the International Federation of **Surveyors** (FIG), Katowice, Poland. (Komitet Organizacyjny PC 85, ul. Kossutha 9, PL 40–833 Katowice, Poland, PO 108.)

June 12–14 19th Annual Canadian Meteorological and Oceanographic Society Congress and Annual General Meeting: Modelling in **Meteorology and Oceanography**, Montreal. (Organizers: Canadian Meteorological and Oceanographic Society, l'Université du Québec à Montréal. (Jean-Guy Cantin or Richard Molfet, 100 Alexis-Nihon Blvd., 3rd Floor, Montreal, Quebec, Canada H4M 2N8; tel.: 514-333-1531.) (Nov. 27, 1984)

June 16–21 Third International Symposium on Analysis of **Seismicity and Seismic Risk**, Liblice, Czechoslovakia. (Z. Schenkova, Geophysical Institute, Bocni II, 14131 Prague 4, Czechoslovakia.)

June 17–19 Symposium on **Degradation of Materials Due to Acid Rain**, Arlington, Va. Sponsor: ACS Division of Industrial and Engineering Chemistry. (Robert Baboian, Texas Instruments, Mail Stn. 10–13, Attleboro, MA 02703; tel.: 617-699-1350 or Nancy Hadlock, ACS, 1155 16th St. NW, Washington, DC 20036.)

June 18–21 Field Conference of the **American Geomorphological Field Group**, Arcata, Calif. (American Geomorphological Field Group Secretariat, Department of Geology and Geophysics, University of California, Berkeley, Berkeley, CA 94720; tel.: 415-642-3993.)

June 24–28 Gordon Research Conference on **Space Plasma Physics**: Plasma Turbulence and Its Roles in Solar-Terrestrial Physics, Andover, N. H. Sponsor: NASA. (T. J. Birmingham, Code 695, NASA/Goddard Space Flight Center, Greenbelt, MD 20771; tel.: 301-344-5461 or T.W. Hill, Department of Space Physics and Astronomy, Rice Univ., Houston, TX 77251; tel.: 713-527-8101 x3513; telex: 556457.)

June 24–28 12th International **Radiocarbon** Conference, Trondheim, Norway. (12th International Radiocarbon Conference, Attn: Pat Ueland, Studies and Academic Administration, Norwegian Institute of Technology, N-7034 Trondheim—NTH, Norway.)

June 26–28 U.S. Symposium on **Rock Mechanics**, Rapid City, S. Dak. Sponsor, South Dakota School of Mines and Technology. (Eileen Ashworth, Chairman, 26th U.S. Symposium on Rock Mechanics, Dept. of Mining Engineering, South Dakota School of Mines and Technology, Rapid City, SD 57701–3995; tel.: 605-394-2344.) (Aug. 14, 1984.)

July 7–19 International Symposium on **Karst Water Resources**, Ankara and Antalya, Turkey. Sponsors: Karst Water Resources Re-

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search Center Project of Hacettepe Univ., U.N., Turkish State Hydraulic Works. (A. Ivan Johnson, Water Resources Consultant, Woodward-Clyde Consultants, 7600 East Orchard Rd., Harlequin Plaza North, Englewood, CO 80111, or Gultekin Gunay, Hydrogeological Engineering Dept., Hacettepe Univ., Engineering Faculty, Beytepe, Ankara, Turkey.)

July 15–17 Fourth International Hydrology Symposium: **Multivariate Analysis of Hydrologic Processes**, Fort Collins, Colo. Sponsors: AGU Hydrology Section, ASCE, IAHS, IWRA, IAHR. (H. W. Shen, Dept. of Civil Engineering, Hydrology and Water Resources Program, Foothills Campus, Colorado State Univ., Fort Collins, CO 80523.)

July 16–19 48th Annual Meeting of the **Meteoritical Society**, Bordeaux, France. (G. Simonoff, CENBG, Université de Bordeaux I, Le Haut-Vigneau, 33170 Gradignan, France.)

July 28–Aug. 2 8th Biennial International **Estuarine Research Conference**, Durham, N. H. Sponsor: Estuarine Research Foundation. (Bjorn Kjerfve, ERF Program Chairman, Belle W. Baruch Institute for Marine Biology and Coastal Research, University of South Carolina, Columbia, SC 29208; tel.: 803-777-4529.)

July 29–Aug. 9 **Tsunami 85**: International Tsunami Symposium of the IUGG Tsunami Commission, Victoria, Canada. (Tsunami 85, P. O. Box 2267, Sidney, B.C., Canada V8L 3S8; tel.: 604-656-8345.)

July 31–Aug. 2 International Conference on **Earth Rotation and the Terrestrial Reference Frame**, Columbus, Ohio. Sponsors: COTES MERIT Joint IUGG/IAG/IAU Working Groups. (Ivan I. Mueller, Dept. of Geodetic Science and Surveying, Ohio State University, Columbus, OH 43210–1247.)

Aug. 5–16 IAMAP/IAPSO Joint Scientific Assembly on the **Large Scale Circulation of the Oceans and Atmosphere** and their Interactions, Honolulu, Hawaii. Sponsors: IAMAP, IAPSO, AGU. (AGU, 2000 Florida Ave. N. W., Washington, DC 20009.)

Aug. 5–17 5th Scientific Assembly of IAGA, Prague, Czechoslovakia. (Michael Gadsden, Natural Philosophy Dept., Aberdeen Univ., Aberdeen AB9 2UE, Scotland.)

Aug. 5–17 Symposium on **Magnetic Anomalies over the Margins of Continents and Plates**, Prague, Czechoslovakia. Sponsor: IAGA. (William J. Hinze, Dept. of Geosciences, Purdue Univ., West Lafayette, IN 47907; tel.: 317-494-5982.) (Feb. 7, 1984.)

Aug. 5–17 Special Symposium, Prague, Czechoslovakia. Sponsor: IAGA. (V. Kropacek, IAGA Geophysical Institute, Czechoslovak Academy of Science, Bocni II, 14131 Prague 4-Sporilov, Czechoslovakia.)

Aug. 11–16 Symposium on **Groundwater Contamination and Reclamation**, Tucson, Ariz. Sponsor: AWRA. (Nathan Buras, Dept. of Hydrology and Water Resources, Univ. of Arizona, Tucson, AZ 85721.) (Oct. 16, 1984.)

Aug. 11–16 **Water Demand: Sharing a Limited Resource**—The 21st Annual Conference and Symposium of the American Water Resources Association, Tucson, Ariz. (Yoram Gordon, Greenhorne & O'Mara, Inc., 9001 Edmonston Rd., Greenbelt, MD 20770; tel.: 301-982-2846.) (Oct. 9, 1984.)

Aug. 12–16 International Conference on the Occurrence, Properties, and Utilization of **Natural Zeolites**, Budapest, Hungary. Sponsor: Hungarian Academy of Sciences. (J. Engelhardt, Secretary, Zeolite '85, Central Research Institute for Chemistry, Hungarian Academy of Sciences, H-1525 Budapest, P. O. Box 17, Hungary.) (June 19, 1984.)

Aug. 13–16 **Hydraulics and Hydrology in the Small Computer Age**, Orlando, Fla. Sponsor: Hydraulics Division, American Society of Civil Engineers. (William R. Waldrop, TVA Water Systems Development Branch, PO Drawer E, Norris, TN 37828; tel.: 615-632-4460.) (Oct. 30, 1984.)

Aug. 14–15 Symposium: **Groundwater Contamination and Reclamation**, Tucson, Ariz. Organizer: American Water Resources Association. (Nathan Burns, Department of Hydrology and Water Resources, University of Arizona, Tucson, AZ 85721; tel.: 602-621-5082 or Kenneth D. Schmidt, 4120 North 20th St., suite G, Phoenix, AZ 85016; tel.: 602-956-8711.)

Aug. 18–24 International Workshop on **Hydrological Applications of Space Technology**, Cocoa Beach, Fla. WMO, IAHS. (A. Ivan Johnson, 7474 Upham Court, Arvada, CO 80003.) (Oct. 9, 1984.)

Aug. 19–23 Sixth Gondwana Symposium, Columbus, Ohio. Sponsor: GSA. (D. Elliot, Ohio State Univ., Institute of Polar Studies, 103 Mendenhall, 125 South Oval Mall, Columbus, OH 43210.)

Aug. 19–24 Fourth **Chilean Geological Congress**, Antofagasta, Chile. Sponsor: Dept. of Geociences, Universidad del Norte. (Organizing Committee, Fourth Chilean Geological Congress, Dept. of Geociences, Universidad del Norte, Casilla (Box) 1280, Antofagasta, Chile; tel.: 222010-205.)

Aug. 19–30 **23rd General Assembly of IASPEI**, Tokyo, Japan. (Ryosuke Sato, Secretary-General of the 23rd General Assembly of IASPEI, c/o Inter Group Corp., Akasaka Yamakatsu Bldg., 8-5-32, Akasaka, Minato-ku, Tokyo 107, Japan; tel.: Tokyo (03) 479-5311.)

Aug. 23–25 Workshop on **High Temperature Geothermal Drilling**, Kailua-Kona, Hawaii. Sponsor: Geothermal Resources Council. (Grace Mata, Geothermal Resources Council, P. O. Box 1350, Davis, CA 95617–1350; tel.: 916-758-2360.)

Aug. 26–29 **Third Circum-Pacific Terrane Conference**, Sydney, Australia. Sponsor: Circum-Pacific Council for Energy and Mineral Resources. (Malcolm J. Lennox, Secretary, 3rd Circum-Pacific Terrane Conference, The Earth Resources Foundation, Edgeworth David Building, Univ. of Sydney, New South Wales, Australia 2006.)

Aug. 26–30 International Symposium on **Geothermal Energy**, Kailua-Kona, Hawaii. Sponsor: Geothermal Resources Council. (Geothermal Resources Council, P. O. Box 1350, Davis, CA 95617; tel.: 916-758-2360.)

Aug. 26–30 17th International Symposium on **High-Temperature Heat Exchangers**, Belgrade, Yugoslavia. Sponsor: International Centre for Heat and Mass Transfer. (Y. Mori, Department of Mechanical Engineering, University of Electro-Communications, 1-5-1, Chofugaoka, Chofu, 182 Tokyo, Japan.) (Nov. 27, 1984.)

Aug. 31–Sept. 1 Workshop on **Fractures in Geothermal Reservoirs or Geothermal Exploration**, Kailua-Kona, Hawaii. Sponsor: Geothermal Resources Council. (Geothermal Resources Council, P. O. Box 1350, Davis, CA 95617–1350; tel.: 916-758-2360.)

September International Symposium on **Deep Internal Processes and Continental Rifting**, Chengdu, China. Sponsor: Chinese Lithospheric Committee. (Claude Froidevaux, Université Paris-Sud, Lab. Géophysique-Bât. 510, 91405 Orsay, France).

Sept. 2–4 Symposium on **Coastal Geomorphology, Sedimentary Budgets, and Coastal and River Hydraulics**, Reykjavik. Sponsor: IAHS. (Guttormur Sigbjarnarson, National Energy Authority, Grensasvegur 9, IS-108 Reykjavik, Iceland.)

Sept. 10–13 **Envirosat '85**, Washington, D.C. Organizer: NOAA. (Program Committee, 2nd Envirosat Conference, NOAA/NESDIS, E/ER2, FB#4, Mail Stop D, Washington, DC 20233.) (Nov. 13, 1984.)

Sept. 15–20 International Symposium on **Acidic Precipitation**, Muskoka, Canada. Sponsors: Federal and Provincial Governments of Canada. (Muskoka Conference '85, 112 St. Clair Ave. West, Suite 303, Toronto, Ontario, Canada M4V 2Y3; tel.: 416-961-6505; telex: 06-986766.)

Sept. 15–20 Sixth International Conference on **Basement Tectonics**, Santa Fe, N. Mex. (M. J. Aldrich, Mail Stop D462, Los Alamos National Laboratory, Los Alamos, NM 87545; tel.: 505-667-1495.)

Sept. 16–21 Symposia on **Potassic Volcanism and Etna Volcano**, Catania, Italy. Sponsor: IAVCEI. (G. Frazzetta and G. Lanzafame, Istituto Internazionale di Vulcanologia, V.le R. Margherita, 6, Catania, Italy.) (Dec. 27, 1983.)

Sept. 16–27 Advanced Study Institute on the **Role of Air-Sea Exchange in Geochemical Cycling**, Bombannes, Carcans, France. Organizer: NATO. (P. Buat-Ménard, Centre des Faibles Radioactivités, Domaine du CNRS, Avenue de la Terrasse, BP 1, 91190 Gif sur Yvette, France.)

Sept. 17–21 **AIPG Annual Meeting**, St. Paul, Minn. (Robert E. Prendergast, General Chairman, Geotechnical Engineering Corp., 1925 Oakcrest Ave., Roseville, MN 55113; tel.: 612-636-7744.)

Sept. 17–21 Second International **Mine Water Congress**, Granada, Spain. Sponsor: International Mine Water Association. (R. Fernandez Rubio, School of Mines, Technical Univ. of Madrid, Rios Rosas 21, Madrid 3, Spain.)

Sept. 19–23 International Symposium on **Scientific Basis for Water Resources Management**, Jerusalem. Sponsors: Israel Assoc. of Hydrology, IAHS. (SBWRM Israel '85, The Israel Assoc. of Hydrology, P. O. Box 6381, Jerusalem, Israel.) (July 31, 1984.)

Sept. 19–23 IAHS International Symposium on the Scientific Basis for **Water Resources Management** SBWRM–Israel '85, Jerusalem. (Kenes, PO Box 50006, Tel Aviv 61500, Israel.)

Sept. 23–26 Biannual Conference of the **Western Federation of Professional Land Surveyors** (WFPLS), Portland, Oregon. (Grant E. Heppenstall, 17308 Booth Ave. SE, Bothell, WA 98012; tel.: 206-481-8532.)

Sept. 23–Oct. 2 Advanced Study Institute on the **Tectonic Evolution of the Tethyan Regions**, Istanbul, Turkey. Sponsor: NATO. (B. C. Burchfiel, 54–1010, Massachusetts Institute of Technology, Cambridge, MA 02139; tel.: 617-253-7919.)

Sept. 28–29 16th Annual Geomorphology Symposium on **Hillslope Processes**, Buffalo, N. Y. (Athol. D. Abrahams, Department of Geography, State Univ. of New York at Buffalo, Buffalo, NY 14260; tel.: 716-636-2289).

Sept. 30–Oct. 6 UNESCO/IAHS International Symposium on **Glacier Mass Balance Fluctuations and Runoff**, Alma Alta, USSR. (V. M. Kotlyakov, Institute of Geography, USSR Academy of Sciences, Staromonetry St. 29, Moscow 109017, USSR.)

October Advanced Study Institute on **Physiological Ecology of Photosynthetic Picoplankton in the Ocean**, San Miniato, Italy. Sponsor: NATO Scientific Affairs Division. (Trevor Platt, Marine Ecology Laboratory, Bedford Institute of Oceanography, Box 1006, Dartmouth, Nova Scotia, Canada B2Y 4A2; tel.: 902-426-3793; telex: 01931552.)

Oct. 7–9 IEEE International **Geoscience and Remote Sensing** Symposium (IGARSS '85) and Commission F Meeting of USNC/URSI, Amherst, MA. (Calvin T. Smith, Technical Program Chairman, Department of Electrical and Computer Engineering, Engineering Bldg. E, Room 20, Univ. of Massachusetts, Amherst, MA 01003.)

Oct. 7–10 Workshop on the Statistical Aspects of **Water Quality Monitoring**, Burlington, Ontario, Canada. Organizer: National Water Research Institute of Environment Canada. (A. El-Shaarawi, Aquatic Physics and Systems Division, NWRI, Canada Centre for Inland Waters, PO Box 5050, Burlington, Ontario, Canada L7R 4A6; tel.: 416-637-4534; or R. E. Kwiatkowski, Water Quality Branch, IWD, Place Vincent Massey, Ottawa, Ontario, Canada K1A 0E7; tel.: 819-997-1921.)

Oct. 9–10 International Symposium on Management of **Hazardous Chemical Waste Sites**, Winston-Salem, N. C. Sponsors: AGU, U.S. National Committee of International Assoc. of Engineering Geology, Assoc. of Engineering Geologists. (Norman Tilford, Dept. of Geology, Texas A&M Univ., College Station, TX 77843–3115; tel.: 409-845-9682.)

Oct. 10–12 Conference on **Heat and Detachment in Crustal Extension on Continents and Planets**, Sedona, Ariz. Sponsor: Lunar and Planetary Institute, USGS, GSA. (Pam Jones, LPI Projects Office, Lunar and Planetary Institute, 3303 NASA Road 1, Houston, TX 77058; tel.: 713-486-2150.) (July 31, 1984.)

Oct. 14–18 Dissertation Symposium on **Chemical Oceanography** (DISCO), Honolulu, Hawaii. (Neil Andersen, Director, Marine Chemistry Program, National Science Foundation, Washington, DC 20550.)

Oct. 14–18 U.S.-China Bilateral Symposium on the Analysis of **Extraordinary Flood Events**, Nanjing, China. Sponsors: USGS, Bureau of Hydrology of the Ministry of Water Resources and Electric Power of the People's Republic of China. (Marshall E. Moss, Chief, SurfaceWater Branch, U.S. Geological Survey, 415 National Center, Reston, VA 22092; tel.: 703-860-6837.) (Sept. 11, 1984.)

October 15–17 International Symposium on **Variational Methods in Geosciences**, Norman, Okla. Sponsors: AGU, The Cooperative Institute for Mesoscale Meteorological Studies, Univ. of Oklahoma College of Geosciences. (Symposium Arrangements Chairman, CIMMS, University of Oklahoma, 401 E. Boyd, Norman, OK 73019 or Y. K. Sasaki, Univ. of Oklahoma, 815 Jenkins, Norman, OK 73019.)

Oct. 21–25 International Conference on **Arid Lands: Today and Tomorrow**, Tucson, Ariz. Sponsors: UNESCO, Univ. of Arizona. (G. P. Nabhan, Office of Arid Land Studies, Univ. of Arizona, Tucson, AZ 85721.)(Nov. 13, 1984)

Oct. 28–31 **GSA 1985 Annual Meeting**, Orlando, Fla. (Sue Beggs, Meetings Manager, GSA, P. O. Box 9140, Boulder, CO 80301; tel.: 303-447-2020.)

Oct. 28–31 **AGU Chapman Conference on Magnetotail Physics**, Laurel, Md. (AGU Meetings, 2000 Florida Ave., N. W., Washington, DC 20009.)

Oct. 28–Nov. 1 International Conference on **Coal Science**, Sydney, Australia. Sponsor: International Energy Agency. (R. W. Hinde, Executive Secretary, CSIRO, Div. of Fossil Fuels, P. O. Box 136, North Ryde, NSW 2113, Australia.) (July 31, 1984.)

Nov. 4–8 Physics of **Fracturing and Seismic Energy Release**, Liblice, Czechoslovakia. (J. Kozak, Geophysical Institute, Bocni II, 14131 Prague 4, Czechoslovakia.)

Nov. 11–14 IAHS/ABRH International Symposium on **Water Resources Management** in Metropolitan Regions, Sao Paulo, Brazil. (Simposia Brasileiro de Hidrologia e Recursos Hidricos, PO Box 11.142 Sao Paulo S.P. Brazil.)

Nov. 13–15 Meeting on **Shuttle Environment and Operations** II, Houston, Tex. Organizer: American Institute of Aeronautics and Astronautics. (Billy M. McCormac, Lockheed R&DD, D91–30/B202, 3251 Hanover St., Palo Alto, CA 94304; tel.: 415-424-2816.)

Dec. 9–13 **AGU Fall Meeting**, San Francisco, Calif. (Meetings, AGU, 2000 Florida Ave., N. W., Washington, DC 20009.)

1986

January Symposium on **Geotechnical Applications of Remote Sensing and Remote Data Transmission**, New Orleans, La. Sponsor: American Society for Testing and Materials (A. Ivan Johnson, Woodward-Clyde Consultants, Harlequin Plaza-North, 7600 E. Orchard Road, Englewood, CO 80111; tel.: 303-425-5610.)

Feb. 16–21 Eighth Australian Geological Convention: **Earth Resources in Time and Space**, Adelaide, Australia. Organizer: Geological Society of Australia. (M. A. Cobb, Convenor, Publicity and Promotions Committee, Box 292, Eastwood, SA 5063 Australia.)

March 24–28 Pacific Conference on **Marine Technology**: PACON 86, Honolulu, Hawaii. Organizers: Marine Technology Society–Hawaii Section, Center for Engineering Research–University of Hawaii at Manoa. (N. Saxena, CNOC Chair in MC&G, Code 68 GX, Department of Oceanography, Naval Postgraduate School, Monterey, CA 93943; tel. 408-646-3268.)

March 31–April 1 Third International Symposium on **River Sedimentation**, Jackson, Miss. Sponsor: School of Engineering, University of Mississippi. (S. Y. Wang, School of Engineering, Univ. of Mississippi, University, MS 38677; tel.: 601-232-7219 or (Chinese participants only) Dai Dingzhong, Department of Science and Technology, Ministry of Water Resources and Electric Power, PO Box 2906, Beijing, China; tel.: 362018, 367971.)

April 9–11 International Symposium on Comparison of **Urban Drainage Models With Real Catchment Data**, Dubrovnik, Yugoslavia. Sponsors: IAHR, IAWPRC, Yugoslav Association for Hydraulic Research, ISKRA-DELTA (Ljubljana, Yugoslavia), Institute of Hydraulic Engineering of the University of Belgrade. (W. James, McMaster University, Hamilton, Ontario, Canada, L8S 4L7; tel.: 416-527-6941.)

April 21–24 International Symposium on **Environmental Geotechnology**, Allentown, Pa. (H. Y. Fang, Symposium Chairman, Geotechnical Engineering Division, Dept. of Civil Engineering, Lehigh Univ. No. 13, Bethlehem, PA 18015.)

May 18–21 International Symposium on **Flood Frequency and Risk Analyses**, Baton Rouge, La. Co-sponsor: AGU. (Vijay Singh, Lousiana State Univ., Dept. of Civil Engineering, Baton Rouge, LA 70803–6405; tel.: 504-388-6697.)

May 19–23 **AGU Spring Meeting**, Baltimore, Md. (AGU, 2000 Florida Ave., N.W. Washington, DC 20009.)

June Conference on **Study and Mitigation of Hazards**, San Martin. Sponsor: Tsunami Society. (Hazards Conference, Box 60536, Las Vegas, NV 89160.) (Jan. 3, 1984.)

June 1–11 18th Congress of the International **Federation of Surveyors**, Toronto, Ontario, Canada. Hosts: Canadian Institute of Surveying. (FIG Congress '86, P. O. Box 186, Station Q, Toronto, Ontario M4T 1M2, Canada.)

June 3–6 Advancements in **Aerodynamics, Fluid Mechanics, and Hydraulics**, Minneapolis, Minn. Sponsors: Aerospace, Engineering Mechanics, and Hydraulic divisions of ASCE. (H. Stefan, St. Anthony Falls Hydraulic Laboratory, Department of Civil and Mineral Engineering, Mississippi River at Third Ave., S.E., Minneapolis, MN 55414; tel.: 612-373-2782.) (Oct. 23, 1984)

July 7–11 Geocongress '86: An International **Earth Science** Congress, Johannesburg, South Africa. Sponsors: Geological Society of South Africa, IUGS. (Symposium Secretariat, S. 339, CSIR, PO Box 395, Pretoria, Republic of South Africa 0001.)

Aug. 4–8 International Symposium on Drainage Basin **Sediment Delivery**, Albuquerque, N. M. Sponsors: International Commission on Continental Erosion of the International Association of Hydrological Sciences, University of New Mexico. (R. F. Hadley, Secretary ICCE, c/o Department of Geography, Univ. of Denver, Denver, CO 80208–0183; tel.: 303-871-2672.)

August 11–15 Fourth International **Kimberlite Conference**, Perth, Australia. Sponsor: Geological Society of Australia. (J. D. Lewis—Secretary, Fourth International Kimberlite Conference, Geological Survey of Western Australia, Mineral House, 66 Adelaide Terrace, Perth, Western Australia 6000.)

Aug. 24–30 12th International Sedimentological Congress: **Sediments Down-Under**, Canberra, Australia. Sponsors: International Association of Sedimentologists, Geological Society of Australia, Geological Society of New Zealand, Bureau of Mineral Resources (geology and geophysics). (12th International Sedimentological Congress, ACTS, GPO Box 1929, Canberra ACT 2601, Australia; tel.: 062–49–8015; international: 6162 498015; telex: AA62260, UNIHSE-ACTS.)

Sept. 7–12 Second International Conference on **Paleoceanography**, Woods Hole, Mass. (W. A. Berggren, Dept. of Geology and Geophysics, Woods Hole Oceanographic Institution, Woods Hole, MA 02543.)

Sept. 7–12 IGS Symposium on **Remote Sensing in Glaciology**, Cambridge, England. (H. Richardson, International Glaciological Society, Lensfield Rd., Cambridge CB2 1ER, England.)

Dec. 8–12 **AGU Fall Meeting**, San Francisco, Calif. (AGU, 2000 Florida Ave., N. W., Washington, DC 20009.)

AAAS American Association for the Advancement of Science
AAPG American Association of Petroleum Geologists
ACS American Chemical Society
AIPG American Institute of Professional Geologists
AMS American Meteorological Society
ASCE American Society of Civil Engineers
AWRA American Water Resources Association
GSA Geological Society of America
IAG International Association of Geodesy
IAGA International Association of Geomagnetism and Aeronomy
IAHR International Association for Hydraulic Research
IAHS International Association of Hydrological Sciences
IAMAP International Association of Meteorology and Atmospheric Physics
IAPSO International Association for the Physical Sciences of the Ocean
IASPEI International Association of Seismology and Physics of the Earth's Interior
IAVCEI International Association of Volcanology and Chemistry of the Earth's Interior
ICSU International Council of Scientific Unions
IUGG International Union of Geodesy and Geophysics
IUGS International Union of Geological Sciences
IWRA International Water Resources Association
MSA Mineralogical Society of America
NWWA National Water Well Association
SEG Society of Exploration Geophysicists
SEPM Society of Economic Paleontologists and Mineralogists
URSI International Union of Radio Science
WMO World Meteorological Organization

AGU

E&HR Committee Reports

The E&HR (Education and Human Resources) Committee engages in a variety of activities of direct interest to members. This report is to acquaint you with current and future activities of the committee and with the membership of the committee itself. We welcome your suggestions and comments on any relevant topics.

Ongoing activities of the committee include oversight of the AGU Minority and June Bacon-Bercey scholarships, job centers and evening panel sessions at meetings, and response to various requests from the AGU Council. The committee maintains a liaison with the Scientific Manpower Commission and with the Association for Women Geoscientists.

At the most recent meeting of the committee a number of recommendations or decisions were made:

Child Care Facilities at Meetings. The AGU staff was requested to collect and publish in *Eos* lists of local child care facilities in San Francisco and Baltimore, as suggested by the convention bureaus of those cities. In addition, the committee will try to help members arrange cooperative baby-sitting on a volunteer basis. A notice will be published soon in *Eos*, outlining the plan in more detail. We hope to get something going in time for the 1985 AGU Spring Meeting.

Student Participation in AGU. A students-only booth will be set up at AGU meetings, manned by AGU staff, officers, and committee members. Students can use this booth to contact each other or to make suggestions to AGU. An effort will be made to advertise the Job Center more effectively. Low-cost housing in Baltimore and San Francisco will be included in the options for meeting hotels. We are exploring possibilities for travel grants to help students attend meetings and for awards to outstanding student papers at meetings.

Two-Career Couples. We sponsor evening panel sessions at the AGU Spring and Fall Meetings at which panelists and audience discuss their experiences and problems. Extensive notes from the sessions are published in *Eos* and may eventually be collected into a small publication containing profiles of geophysicists. We plan to include some questions on this subject in the survey which will be mailed to members this spring. Statistics from the survey will be published in *Eos*.

Precollege Education. The committee has produced three career booklets over the years: two on all fields of geophysics and one on oceanography. These booklets are available at no cost and are useful for members asked to participate in local career day programs. The booklets will be advertised in the journals of the National Science Teachers Association and the National Association of Guidance Counselors.

Films, Tapes, and Slide Shows. The committee has requested AGU staff to collect listings of films, tapes, and slides on topics of interest to geophysicists. The listing will include educational level, address of distributor, and leasing arrangements.

Miscellaneous. The committee is also looking into the possibility of establishing an AGU Distinguished Lectureship program and of sponsoring short courses at meetings. *Eos* will occasionally publish abstracts of reports on employment and scientific manpower, of interest to geophysicists.

Current members of the committee are Constance Sancetta, Chair (Oceanography; Lamont-Doherty), Miguel Marino (Hydrology; University of California at Davis), Leslie Meredith (Solar-Planetary; National Aeronautics and Space Administration, Goddard Space Flight Center), Stewart Smith (Seismology; University of Washington), Keith Sverdrup (Tectonophysics; University of Wisconsin), Petr Vanicek (Geodesy; University of New Brunswick), and Robert Manka (Solar-Planetary; National Academy of Sciences). Please contact any member of the committee if you have questions, suggestions, or comments on any of the topics mentioned above.

Constance Sancetta, *Chairman*

GAP

Separates

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Exploration Geophysics

remarkably similar. Event amplitudes are small or undetectable at offsets out to about 2 000 ft, but at offsets from 2 500 to 3 600 ft amplitudes are higher than those of any other event. Head waves originating at the critical distance are weak but detectable.

seismic reflection data is analytically determined. The three-dimensional (3-D) velocity distribution obtained by Born inversion is shown to be directly related to the 3-D reflectivity function obtained by wave-equation migration for full bandwidth or band-limited data. The relationship is obtained by the reformulation of migration and Born inversion methods as inverse source problems for the 3-D wave equation. The reformulation leads to a definition of the reflectivity function as the source function for the wave equation. It also leads to determination of the Born inversion results by applying the algorithm for wave-equation migration to modified surface data. The modified data are simply related to the CMP stacked data. Alternatively, Born inversion results may be obtained directly from the migrated section. Results from synthetic and recorded data are presented and found to be consistent with the theoretical developments.
GEOPHYSICS, VOL. 49, NO. 12

0930 Seismic methods
RESIDUAL MIGRATION: APPLICATIONS AND LIMITATIONS
Daniel H. Rothman (Department of Geophysics, Stanford University, Stanford, California 94305) Stewart A. Levin and Fabio Rocca

The correct migration of seismic data depends on the accuracy of the chosen velocity model. Rocca and Salvador (1982) showed that small errors in the velocity model may be efficiently corrected by applying a residual migration to previously migrated data, rather than remigrating the original data with a corrected velocity field. This decreases computational cost relative to a full migration, and allows the initial migration to be done with a less accurate but faster algorithm than would otherwise be required.

The possible advantages are many. The overall cost of migration may be reduced, a consideration especially important when migrating 3-D data sets. Migration quality may be improved, because the location of mispositioned reflectors can be corrected and because of the freedom to choose initial migration with a high dip, low dispersion method such as Stolt migration. Interactive residual sharpening of the migrated image also becomes feasible.

We discuss the theoretical and practical limitations of residual migration and quantify the related reductions of effective dip, velocity, and frequency after initial migration. We determine how accurate the initial migration velocity must be to justify use of this approach and analyze aliasing and numerical artifacts. Field data examples using Kirchhoff summation and finite-difference migration illustrate the features and drawbacks of the method.
GEOPHYSICS, VOL. 50, NO. 1

0930 Seismic methods
AN EXAMINATION OF THE EXPONENTIAL DECAY METHOD OF MIXED PHASE WAVELET ESTIMATION
Gregory D. Lazear (Conoco Inc., Box 1267, Ponca City, OK 74601)

Signal processing theory states that an isolated wavelet which is causal and mixed phase may be converted to minimum phase by applying an exponential decay of amplitude with time. The exponential decay might therefore be a useful preprocessing step for seismic wavelet estimation since many estimation methods require that the wavelet in the data be minimum phase. This is the basis of a method proposed by Taner and Coburn (1980).

The wavelets in a seismic trace, however, are generally not isolated, but instead are convolved with a densely populated reflection coefficient series causing severe wavelet overlap. Wavelet estimation is generally done using a window of data from the seismic trace which excludes refractions, surface waves, and data with poor [illegible]

[illegible]
GEOPHYSICS, VOL. 49, NO. 12

0930 Seismic methods
A CRITIQUE OF SEISMIC DECONVOLUTION METHODS
[illegible]
GEOPHYSICS, VOL. 49, NO. 12

Geochemistry

1410,3715,5599 General (Ion Composition)
RECENT STRATOSPHERIC NEGATIVE ION COMPOSITION MEASUREMENTS BETWEEN 22 AND 45 KM ALTITUDE
E. Arijs, D. Nevejans, J. Ingels and P. Frederick (Belgian Institute for Space Aeronomy, Ringlaan 3, B-1180 Brussels, Belgium)

Negative ion spectra obtained during three balloon flights performed in June 1982, September 1982 and September 1983 are reported. The lower altitude limit of the measurements is imposed by the decrease of the instrument sensitivity and the upper limit by present ballooning techniques. At high altitudes the ion spectra are disturbed by contamination, whereas at low altitudes ion cluster break up is a severe problem. Nevertheless knowledge of relative abundances of the different negative ion mass peaks, mainly belonging to the $NO_3^-(HNO_3)_n$ and $HSO_4^-(HNO_3)_m(H_2SO_4)_l$ cluster families allows the derivation of concentrations of H_2SO_4 in the altitude region of 22 to 45 km. At 45 km an increased SO_2 mixing ratio, possibly due to volcanic activities, was estimated from the negative ion mass spectra. The data are discussed in terms of previous measurements and models. Special interest is given to the sulfur chemistry and the implications on aerosol formation.
J. Geophys. Res., D, Paper 4D1417

1410 Chemistry of the atmosphere
MEASUREMENT OF NITRIC OXIDE FROM 7 TO 32 KM AND ITS DIURNAL VARIATION IN THE STRATOSPHERE
[illegible]

than 57° coincided even in detail to within 5 % between 22 and 32 km. The NO concentration at 32 km gradually decreased as the SZA increased from 70° to 90° at sunset at which time it rapidly decreased by more than order of magnitude in 10 minutes.
(Nitric oxide, stratosphere, diurnal variation)
J. Geophys. Res., D, Paper 4D1424

Geomagnetism and Paleomagnetism

2558 Time variations, diurnal to secular
RECURRENT GEOMAGNETIC ACTIVITY – EVIDENCE FOR LONG-LIVED STABILITY IN SOLAR WIND STRUCTURE
H. H. Sargent III (NOAA/ERL/Space Environment Laboratory, 325 Broadway, Boulder, CO 80303)

The simple index described clearly shows periods of recurrent geomagnetic behavior. The index is based on half-day values of the geomagnetic aa-index for 1868 through 1983, which reveal rather lengthy periods when geomagnetic activity patterns are faithfully repeated every 27 days. It is shown that these recurrent periods occur at the end of each sunspot cycle; that they end fairly abruptly with the beginning of a new sunspot cycle; that they tend to last significantly longer when associated with even-numbered sunspot cycles; and that the effect is clearly centered on a 27-day repetition rate. The 27-day Recurrence Index indicates those regularly occurring times when the solar wind structure remains relatively stable beyond 1 AU for periods of 1-1/2 to 5 years. Correlations have been reported between the index and auroral heights and even the global albedos of Titan and Neptune. (Recurrent geomagnetic activity, solar wind structure, coronal hole evolution).
J. Geophys. Res., A, Paper 4A8206

Hydrology

3715 Chemical composition and chemical interactions
A COUPLED ONE-DIMENSIONAL RADIATIVE-CONVECTIVE, CHEMISTRY-TRANSPORT MODEL OF THE ATMOSPHERE. 1. MODEL STRUCTURE AND STEADY-STATE PERTURBATION CALCULATIONS
A. J. Owens, (Engineering Department, E304, E. I. du Pont de Nemours & Co., Inc., Wilmington, DE, 19898), C. H. Hales, D. L. Filkin, C. Miller, J. M. Steed, and J. P. Jesson

An atmospheric model composed of a narrow-band radiative-convective (RC) code coupled with a one-dimensional chemistry and transport (CT) code is described. The RC model, formulated in log-pressure coordinates, includes accurate solar absorption calculations for O_3, O_2, H_2O, and CO_2. Infrared heating and cooling by CO_2, O_3, and H_2O are calculated with a narrow-band formulation, while broader-band formulations are used for CH_4, N_2O, CFC 11, and CFC 12. The atmospheric chemistry and transport model uses photochemical reaction rate data from JPL [illegible]

[illegible]

August the projected needle area index varied from [illegible] to 2.6, whereas total canopy conductance increased by 100% due to variations in climate (50%), needle area (30%) and stomatal efficiency (20%). Comparison between three forests indicated that it was more important to understand the mechanisms behind the seasonal variation of G than to assess differences in G between forests, these latter differences being remarkably small. (Surface resistance, transpiration, Penman equation).
Water Resour. Res., Paper 4W1372

3160 Runoff and Streamflow
A COMPARISON OF RAINFALL-RUNOFF MODELING TECHNIQUES ON SMALL UPLAND CATCHMENTS
Keith M. Loague and R. Allan Freeze (Department of Geological Sciences, University of British Columbia, Vancouver, Canada, V6T 2B4)

This paper reports a set of model-performance calculations for three event-based rainfall-runoff models on three data sets involving 269 events from small upland catchments. The models include a regression model, a unit-hydrograph model, and a quasi-physically based model. The catchments are from the Washita River Experimental Watershed, Oklahoma; the Mahantango Creek Experimental Watershed, Pennsylvania; and the Hubbard Brook Experimental Forest, New Hampshire. Model performance was assessed for a verification period that is carefully distinguished from the calibration period. Performance assessment was carried out both in forecasting mode and in design mode. The results show surprisingly poor forecasting efficiencies for all models on all data sets. The unit-hydrograph model and the quasi-physically based model have little forecasting power; the regression model is marginally better. The performance of the models in design mode is better. The regression model and the unit-hydrograph model showed acceptable predictive power, but the quasi-physically based model [illegible]
Water Resour. Res., Paper 4W1291

[illegible]

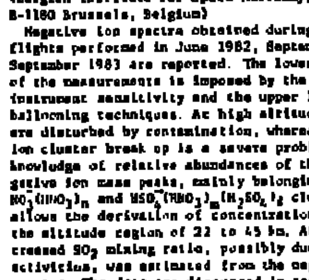
controlled by vapor diffusion. Diffusion through or along the ice matrix is slow, whereas diffusion from the air to within separate grains is comparatively rapid. Thus mixing occurs in the vapor phase and the exchange with the local ice involves all the water molecules. A quantification of these concepts is applied to the diffusion of oxygen-isotopic depth-profiles in southern Greenland and at Dome C, Antarctica. It successfully describes the smoothing of measured profiles. The smoothing rate is strongly dependent on temperature and density of the firn. (Snow, firn, metamorphism, isotope).
J. Geophys. Res., D, Paper 4D1427

Meteorology

3715 Chemical Composition
STRATOSPHERIC H_2O AND HNO_3 PROFILES DERIVED FROM SOLAR OCCULTATION MEASUREMENTS
H. Fischer, F. Fergg and D. Rabus (Meteorological Institute Munich, Theresienstr. 37, 8 Munich 2, F.R.G.), P. Burkert (Kayser Threde GmbH, Würmtalstraße 2, 8 Munich 70, F.R.G.)

Compact two-channel radiometers for solar occultation experiments have been constructed in order to measure stratospheric trace gases. The instruments can be used as filter- or correlation-type radiometers depending on the trace gas under investigation. Within [illegible]
J. Geophys. Res., D, Paper 4D1409

3725 Convection, turbulence, and diffusion
COMPARISONS OF VERTICAL WINDS MEASURED WITH THE CHATANIKA AND POKER FLAT RADARS
D. J. Watkins, [illegible] (Geophysical Institute, University of Alaska, Fairbanks, Alaska 99701)
[illegible]



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magnitude of electric charge transferred to a riming pellet of soft-hail when ice crystals collide then separate are sensitive functions of the liquid water content and the temperature. Certain differences between those results obtained with crystal/rimer relative velocities of ~3 m s⁻¹ and those of other workers at ~10 m s⁻¹ have been reconciled in the present work in terms of a velocity dependence of the sign of the charge transfer. By measuring the charge transferred to two ice targets of different size, an estimate has been made of the product of collision and separation probabilities of crystals interacting with a 5 mm diameter target. (Thunderstorm charging, lightning).
J. Geophys. Res., D, Paper 4D1420

3735 Electrical Phenomena
MEASUREMENTS OF ION MOBILITY TO 30 KM
J. M. Rosen (Dept. of Physics and Astronomy, University of Wyoming, Laramie, WY 82071), D. J. Hofmann, W. Gringel

Balloon-borne measurements of atmospheric electrical parameters made during the last several years indicate that there has been a significant change in the average small ion mobility. In addition, on some soundings abrupt changes in the ion mobility profile have been noted. These variations provide an unusual opportunity to experimentally study the functional relationships between mobility, ion density, conductivity and the recombination coefficient in the stratosphere. Within the uncertainties involved it is found that the measurements support the simple, predicted theoretical relationships between these various parameters. If fluctuations in ion mobility are in fact a usual occurrence, then this work indicates that variations frequently observed in the ion concentration are probably related to changes in ion mobility rather than aerosol variations, as is usually assumed. One somewhat surprising result predicted by the functional relationships between the electrical parameters indicates that the ambient conductivity may be relatively insensitive to mobility variations.
J. Geophys. Res., D, Paper 4D1426

3735 Electrical Phenomena
ELECTRON WAVES IN THE ELECTRICAL BREAKDOWN OF GASES, WITH APPLICATION TO THE DART LEADER IN LIGHTNING
H. Jurenka and E. Barreto (ASRC, ES 324, SUNY at Albany, 1400 Washington Ave., Albany, NY 12222)

The fluid dynamical analysis of an electron gas has been recently reviewed and applied to the final stage of an electrical breakdown in gases. In particular, it has been used to describe the propagation of ionizing waves that move with speeds of $10^4 - 10^7$ m/sec. Numerical methods are usually used to find shock-like solutions. To find analytical solutions, we have reduced the original system of electron fluid (continuity, momentum, and energy conservation) and Maxwell's equations to single non-linear differential equations. These model equations were solved analytically. Here, this analysis is improved by including a source of electrons due to collisional ionization [illegible]
J. Geophys. Res., D, Paper 4D1419

3745 Gravity waves, tides, and compressional waves
[illegible]

3760 Ionic Interactions and Processes
[illegible]
J. Geophys. Res., C, Paper 4C1331

3770 Particles and Aerosols
AEROSOL SIZE DISTRIBUTIONS IN AIR MASSES ADVECTING OFF THE EAST COAST OF THE UNITED STATES
[illegible]
J. Geophys. Res., D, Paper 4D1281

3780 Storms
THE JUNE 22 TROPICAL SQUALL LINE OBSERVED DURING COPT 81 EXPERIMENT: ELECTRICAL SIGNATURE ASSOCIATED WITH DYNAMICAL STRUCTURE AND PRECIPITATION
[illegible]

stationary dynamics and precipitation pattern of the squall line. (Thunderstorm, dynamics, electric field, squall line).
J. Geophys. Res., D, Paper 4D1418

Oceanography

4760 Oceanography (Sea Ice)
PROCESSES AND IMAGERY OF FIRST-YEAR FAST ICE DURING THE MELT SEASON
Benjamin Holt (Jet Propulsion Laboratory, M/S 169-236, 4800 Oak Grove Drive, Pasadena, CA 91109) and Susan A. Digby.

An analysis of first-year fast sea ice during the melt season has been made using surface measurements and aircraft radar and photographic imagery obtained during a field study near Prince Patrick Island in the Canadian Archipelago from 13 June to 13 July 1982 and satellite imagery from Landsat and Seasat. Distinct changes observed in the properties of the snow layer and the sea ice were a temporary increase in small-scale surface roughness due to formation of nodules of ice at the snow/ice interface; extensive snow melt and surface flooding; development of surface water drainage networks and low topography around fractures and seal breathing holes; and a rapid draining of much of the surface water. From the extensive salinity profiles obtained, two zones of rapid desalination in the first-year ice were observed: one zone extending from the air/ice interface downward toward the center of the ice sheet that resulted from surface warming and drainage of the surface melt water through the ice, and the other zone extending from the sea/ice interface upward toward the center of the ice sheet that resulted from heating and separation of seawater and ice due to a layer of low salinity melt water beneath the ice formed from surface melt water runoff. Aircraft radar imagery detected changes in the amount of surface water and in the development of topography surrounding drainage features. Similar changes were detected in coincident Landsat multispectral scanner (MSS) imagery of the study area, and in Seasat radar imagery and Landsat MSS imagery of the Prince of Wales Strait from July 1978. (sea ice, desalination, remote sensing).
J. Geophys. Res., C, Paper 4C1397

4799 General (Upwelled Filaments)
A COOL ANOMALY OFF NORTHERN CALIFORNIA: AN INVESTIGATION USING IN SITU DATA AND IR IMAGERY
M. M. Rienecker (Oceanography Dept., Naval Postgraduate School, Monterey, CA 93943), C.N.K. Mooers, D.E. Hagan and A.R. Robinson
[illegible]

4799 General (Frontal ...)
[illegible]

Particles and Fields—Interplanetary Space

5310 Cosmic Rays
INTERPLANETARY COSMIC RAY INTENSITY: 1972-1984 AND OUT TO 32 AU
[illegible]

5360 Solar wind interactions with unmagnetized planets
[illegible]

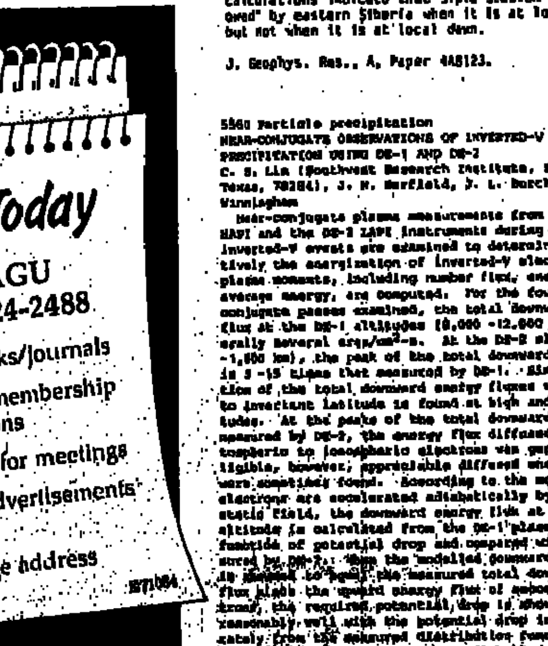
5360 Solar wind interactions with planets
[illegible]

5370 Solar Wind Magnetic Fields
[illegible]

Particles and Fields—Ionosphere

5560 Particle Precipitation
[illegible]
J. Geophys. Res., A, Paper 4A8123

5560 Particle precipitation
[illegible]



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of inverted-V electrons by parallel DC electric field below the DE-1 altitudes could frequently account for the total downward energy flux measured at the DE-2 altitudes. (Inverted-V, electron precipitation).

J. Geophys. Res., A, Paper 4A8255.

5560 Particle Precipitation
MORPHOLOGICAL STUDY OF ENERGETIC ELECTRON PRECIPITATION EVENTS USING THE SATELLITE BREMSSTRAHLUNG X-RAY TECHNIQUE
W. L. Imhof (Lockheed Palo Alto Research Laboratory, Palo Alto, California 94304), J. R. Kilner, and J. B. Reagan

[illegible]

J. Geophys. Res., A, Paper 4A1290.

5599 General (Ionospheric Propagation)
COMPARISON OF HF OBLIQUE TRANSMISSIONS WITH IONOSPHERIC PREDICTIONS
G. H. Millman (General Electric Company, Syracuse, New York 13221) and R. Swanson

[illegible]

Rad. Sci., Paper 4S1296.

5599 General
THE HILAT SATELLITE MISSION
The HILAT Science Team* (P.O. Box 3027, Bellevue, Washington, 98009)

[illegible]

Rad. Sci., Paper 4S1297

Particles and Fields—Magnetosphere

5705 Bow shock waves
Beam Driven Ion Cyclotron Harmonic Resonances in the Terrestrial Foreshock

[illegible]

5705 Bow Shock Waves
HIGH TIME RESOLUTION CHARACTERISTICS OF INTERMEDIATE ION DISTRIBUTIONS UPSTREAM OF THE EARTH'S BOW SHOCK
Douglas W. Potter (Geophysics Program, AK-50, University of Washington, Seattle, Washington 98195)

[illegible]

5705 Bow shock waves
THE MAGNETIC FIELD CHANGE ACROSS THE EARTH'S BOW SHOCK: COMPARISON BETWEEN OBSERVATIONS AND THEORY
Daniel Winterhalter (Institute of Geophysics and Planetary Physics, University of California, Los Angeles, California 90024) Margaret G. Kivelson, Raymond J. Walker, and Christopher T. Russell

[illegible]

5535 Aurorae
A HIGH-LATITUDE PHENOMENOLOGICAL MODEL OF AURORAL PRECIPITATION AND IONOSPHERIC EFFECTS

[illegible]

Rad. Sci., Paper 4S1299

5715 Particles and Fields - Magnetosphere (Electric Fields)
THE FIELD-ALIGNED SCALE LENGTH OF ONE-DIMENSIONAL DOUBLE LAYERS
T. Yamamoto and J.R. Kan (Geophysical Institute, University of Alaska, Fairbanks, Alaska 99701)

[illegible]

J. Geophys. Res., A, Paper 4A8167

5720 Interactions Between Solar Wind and Magnetosphere
COUPLING BETWEEN THE SOLAR WIND AND THE MAGNETOSPHERE: CDAW-6

[illegible]

J. Geophys. Res., A, Paper 4A8270

5720 Electric fields
COHERENT RADAR DOPPLER MEASUREMENTS AND THEIR RELATIONSHIP TO THE IONOSPHERIC ELECTRON DRIFT VELOCITY
E. Nielsen (Max-Planck-Institut für Aeronomie, D-3411 Katlenburg-Lindau, FRG) and K. Schlegel

[illegible]

J. Geophys. Res., A, Paper 4A8274

5736 Magnetic Tail
A METHOD TO MEASURE THE BULK VELOCITY OF AN ENERGETIC ION DISTRIBUTION IN THE PRESENCE OF ION COMPOSITION MIXING

[illegible]

J. Geophys. Res., A, Paper 4A8001

5739 Magnetopause
THE AUGUST 28/29 STORM - I. CROSS-CORRELATIONS OF THE INITIAL MAGNETOPAUSE CROSSINGS AND STORM OBSERVATIONS NEAR THE IONOSPHERIC CONVECTION REVERSAL

[illegible]

5740 Ion Densities and Temperatures
EISCAT MULTIPULSE TECHNIQUE AND ITS CONTRIBUTIONS TO AURORAL IONOSPHERE AND THERMOSPHERE DESCRIPTION

[illegible]

J. Geophys. Res., A, Paper 4A8304

5742 Magnetosheath
LONG DURATION LION ROARS ASSOCIATED WITH QUASI-PERPENDICULAR BOW SHOCKS
Paul Rodriguez (Plasma Physics Division, Naval Research Laboratory, Washington, DC, 20375)

[illegible]

J. Geophys. Res., A, Paper 4A8315

5755 Particles and Field-Magnetosphere (Plasma Instabilities)
HEATING OF LIGHT IONS IN THE PRESENCE OF A LARGE AMPLITUDE HEAVY ION CYCLOTRON WAVE

[illegible]

5755 Plasma instabilities
HIGH AMPLITUDE VLF TRANSMITTER SIGNALS AND ASSOCIATED SIDEBANDS OBSERVED NEAR THE MAGNETIC EQUATORIAL PLANE ON THE ISEE 1 SATELLITE
T. F. Bell (Space, Telecommunications and Radioscience Laboratory, Stanford University, Stanford, California 94305)

[illegible]

J. Geophys. Res., A, Paper 4A8216.

5755 Plasma Instabilities
FAST MAGNETOSPHERIC ECHOES OF ENERGETIC ELECTRON BEAMS
K. Wilhelm (Max-Planck-Institut für Aeronomie, D-3411 Katlenburg-Lindau, FRG), W. Bernstein, P.J. Kellogg and B.A. Whalen

[illegible]

J. Geophys. Res., A, Paper 4A8147.

5759 Plasma Instabilities
THE DOWNSHIFT OF ELECTRON PLASMA OSCILLATIONS IN THE ELECTRON FORESHOCK REGION
H. A. Fuselier (Los Alamos National Laboratory, Los Alamos, New Mexico, 87545) D. A. Gurnett, and R. J. Fitzenreiter

Electron plasma oscillations in the Earth's electron foreshock region are observed to shift above and below the local electron plasma frequency. As plasma oscillations shift downward from the plasma frequency, their bandwidth increases and their wavelength decreases. Observations of plasma oscillations well below the plasma frequency are correlated with times when ISEE-1 is far downstream of the electron foreshock boundary. Although wavelengths of plasma oscillations below the plasma frequency satisfy $k\lambda_{De} \approx 1$, the Doppler-shift due to the motion of the solar wind is not sufficient to produce the observed frequency shifts. A beam-plasma interaction with beam velocities on the order of the electron thermal velocity is suggested as an explanation for plasma oscillations above and below the plasma frequency. Frequency, bandwidth, and wavelength changes predicted from the beam-plasma interaction are in good agreement with the observed characteristics of plasma oscillations in the foreshock region. (Plasma oscillations, Langmuir waves, foreshock).

J. Geophys. Res., A, Paper 4A8227

5760 Plasma Motion, Convection, or Circulation
SUPERTHERMAL ION SIGNATURES OF AURORAL ACCELERATION PROCESSES
T. E. Moore (Space Science Laboratory, NASA/Marshall Space Flight Center, Huntsville, AL 35812), C. R. Chappell, M. Lockwood, and J. H. Waite, Jr.

The Retarding Ion Mass Spectrometer on the Dynamics Explorer-1 spacecraft has generated a unique data set which documents, among other things, the occurrence of non-Maxwellian superthermal features in the auroral topside ionosphere distribution functions. In this paper, we provide a representative sampling of the observed features and their spatial morphology as observed at altitudes in the range from a few thousand kilometers to a few Earth radii. At lower altitudes, these features appear at auroral latitudes separating regions of polar cap and subauroral light ion polar wind. The most common signature is the appearance of an upgoing energetic tail having conical lobes representing significant ion heat and number flux in all species, including O+. Transverse ion heating below the observation point at several thousand kilometers is clearly associated with O+ outflows. In some events observed, transverse acceleration apparently involves nearly the entire thermal plasma, the distribution function becomes highly anisotropic with $T_\perp > T_\parallel$, and may actually develop a minimum at zero velocity, i.e., become a torus having as its axis the local magnetic field direction. At higher altitudes, the localized dayside source region appears as a field-aligned flow which is dispersed tailward across the polar cap according to parallel velocity by anti-sunward convective flow, so that upflowing low energy O+ ions appear well within the polar cap region. While this flow can appear beamlike in a given location, the energy dispersion observed implies a very broad energy distribution at the source, extending from a few tenths of an eV to in excess of 50 eV. On the nightside, upgoing ion beams are found to be latitudinally bounded by regions of ion conics whose half angles increase with increasing separa-

tion from the beam region, indicating low altitude transverse acceleration in immediate proximity to, and below, the parallel acceleration region. These observations reveal a clear distinction between classical polar wind ion outflow and O+ enhanced superthermal flows, and confirm the importance of low altitude transverse acceleration in ionospheric plasma transport, as suggested by previous observations.

J. Geophys. Res., A, Paper 4A8250

5770 Short-period (less than 1 day) variations of magnetic field
AZIMUTHAL PROPAGATION AND FREQUENCY CHARACTERISTIC OF COMPRESSIONAL PC 5 WAVES OBSERVED AT GEOSTATIONARY ORBIT
K. Takahashi (Los Alamos National Laboratory, Los Alamos, NM 87545), P. R. Higbie, and D. N. Baker

Energetic particle data from the 1977-007 and 1979-053 satellites and magnetic field data from the GOES 2 and 3 satellites have been used to study eight compressional Pc 5 wave events observed at geostationary orbit during 1979. All the events occurred on the dayside and most of them were observed during the recovery phase of a geomagnetic storm. By using the data from two of the satellites which were close to each other, we measured the azimuthal phase velocity V_ϕ and azimuthal wave number m for selected intervals. For all those intervals the waves propagated westward in the spacecraft frame, and we obtained $|V_\phi| \approx 4 - 14$ km/s and $|m| \approx 40 - 120$. In addition, harmonics of a local standing Alfvén wave were often present simultaneously with a compressional Pc 5 wave. The frequency of the compressional wave was typically 25% of that of the second harmonic of the Alfvén wave. These observed features are discussed in the light of existing theories of instabilities in the ring current plasma. (geostationary orbit, geomagnetic storm, ring current)

J. Geophys. Res., A, Paper 4A8249

5780 Wave Propagation
AURORAL KILOMETRIC RADIATION: WAVE MODES, HARMONICS AND SOURCE REGION ELECTRON DENSITY STRUCTURES
R. F. Benson (Laboratory for Extraterrestrial Physics, NASA/Goddard Space Flight Center, Greenbelt, MD 20771)

A number of dramatic changes are observed in the characteristics of auroral kilometric radiation (AKR) as the source region plasma to gyrofrequency ratio f_N/f_H varies from 0.1 to 1.1. Most notable of these is a change from right hand polarized extraordinary (X) mode AKR dominance to left hand ordinary (O) mode AKR dominance as f_N/f_H varies from smaller to larger values. In addition to the X and O mode AKR, Z (the slow branch of the X mode) and whistler (W) mode are also observed. The Z mode is observed over all f_N/f_H values, is often confined to the frequency region between f_N and f_H and is typically slightly less intense than the O mode. The W mode is confined to frequencies less than $f_N/2$, suggesting that it is the result of field-aligned ducted signals reaching the satellite from a source at lower altitudes. Harmonic AKR bands, which appear to be of natural rather than instrumental origin and appear to be associated with the O as well as the X mode, are commonly observed. The 2nd harmonic X mode appears to be due to propagating signals, whereas the higher harmonics appear to be confined to low density source regions. The 2nd harmonic associated with the O mode is observed mainly at frequencies above the ambient $2f_H$ value when f_N/f_H is large and below $2f_H$ when f_N/f_H is small. The observations were obtained from some 200 ionograms from 12 passes of the ISIS 1 satellite through AKR source regions. Inferences concerning wave-mode identification are based on comparisons of the observed AKR frequencies with sounder-induced plasma resonances and wave cutoffs of ionospheric reflection traces. Electron density contours from the satellite altitude down to the altitude of the F layer ionization peak were obtained from the sounder data on each pass. Source encounters were made on nearly all of these passes and both the minimum AKR source altitudes and the corresponding f_N/f_H values (which correspond to maximum values) were determined. The deduced $(f_N/f_H)_{max}$ is always less than 0.4 and is typically less than 0.2 during the generation of X-mode AKR. For O-mode AKR, on the other hand, $(f_N/f_H)_{max}$ approaches 0.9. The corresponding AKR source region minimum altitudes extend down to 2400 km. The $(f_N/f_H)_{max}$ values are in excellent agreement with previously published results of the maximum instability temporal growth rates, obtained from the AKR Doppler shifted cyclotron mechanism, as a function of f_N/f_H. The latitudinal extent of the low density, i.e., $N_e \le 100$ cm^{-3}, AKR source regions ranged from a few degrees to more than 20° along the satellite orbit (88° inclination), within the wide-density depletions, i.e., those that extended over many degrees, there were no large enhancements of the ambient f_N/f_H value. These results, which were limited by the ~100 km spatial resolution corresponding to the spacing between topside sounder ionograms, were substantiated on a much finer spatial scale (~10 m for N_e or 1/10 km for ΔN_e) using in situ data from the on-board Langmuir probe which were available for 10 of the 12 passes. The observed lack of large density enhancements within AKR source region density cavities provides additional confidence that the observed intense AKR is cyclotron X-mode radiation rather than plasma frequency O-mode radiation. The observed N_e enhancements, however, were larger than those required to support a feedback mechanism in the source region.

J. Geophys. Res., A, Paper 4A8170

5799 General (Auroral Kilometric Radiation)
COHERENT GENERATION MECHANISM FOR AURORAL KILOMETRIC RADIATION
B. Buti (Physical Research Laboratory, Navrangpura, Ahmadabad 380 009, India), G.S. Lakhina (Indian Institute of Geomagnetism, Colaba, Bombay 400 005, India)

Generation of electromagnetic radiations from the nonlinear interaction of whistler solitons with the upper hybrid waves is investigated. The power emitted from the right handed polarized fundamental whistler sideband of upper hybrid frequency is obtained. The results are applied to the generation of auroral kilometric radiations (AKR) on the auroral field lines in the earth's magnetosphere. The power is found to be larger in the plasma depletion region as compared to high density region. It is found that about $10^3 - 10^4$ whistler solitons filling a volume of $\approx 4 \times 10^6$ km^3 in a region of field aligned auroral cavity can generate the observed AKR power of 10^9 W. Theoretical predictions agree very well with the observed properties of AKR, e.g., frequency range, polarization, peak power and its tendency to occur in the density depletion regions. (Auroral Kilometric Radiation, Coherent Radiation Mechanism, Whistler Solitons)

J. Geophys. Res., A, Paper 4A8246.

5799 General (Particles and Fields - Magnetosphere)
COUPLED LOW ENERGY - RING CURRENT PLASMA DIFFUSION IN THE JOVIAN MAGNETOSPHERE
D. Summers (Department of Mathematics and Statistics, Memorial University, St. John's, Nfld., A1C 5S7, Canada) and G. L. Siscoe

We derive a functional form of the diffusion coefficient appropriate to fully developed, steady state, centrifugally driven turbulence in Jupiter's magnetosphere, incorporating in the diffusion coefficient the effects of the pressure gradient of the ring current. We set up a steady state, coupled diffusion model to describe the simultaneous outwardly diffusing low energy (Iogenic) plasma and the inwardly diffusing ring current plasma. In order to test the hypothesis that the pronounced reduction in the radial diffusion coefficient (implied by the existence of the Io plasma ramp) is caused by the pressure gradient of the ring current, we seek solutions to the model under the condition that a reduced form of the diffusion coefficient takes on a minimum value at some point within the spatial extent of the ramp, i.e., within the range $7 \le L \le 8$, where L is radial distance in units of Jovian radius R_J. This condition leads to several necessary conditions on the model parameters and the values of the ring current density and density gradient at the minimum point. We find that high energy (0.5-1.05 MeV) ring current particles, which have been previously observed and whose density decreases inwardly by several orders of magnitude over the range $6 \le L \le 10$, cannot cause a sufficient inhibition of Iogenic plasma diffusion to cause the ramp. Further, we show that for ring current pressure to cause the ramp there must exist a component of the ring current particle population with sufficiently low thermal energy and with sufficiently high density, i.e., corresponding to an Iogenic plasma flux of 2×10^{28} sec^{-1} [10^{28} sec^{-1}], the ring current particles must have thermal energies of less than 3.9 keV [488 eV], and corresponding ring current particle densities at, say, L = 7.5 must exceed by two orders of magnitude those observed for the high energy component. Our model predicts that the density of the dense, low energy ring current particles decreases only by about an order of magnitude over the range $6 \le L \le 10$. We provide representative numerical solutions for the density profiles of the Iogenic and ring current plasmas. (Jupiter, magnetosphere, plasma diffusion).

J. Geophys. Res., A, Paper 4A8139

Physical Properties of Rocks

6110 Elasticity, fracture, and flow
WELLBORE BREAKOUTS AND IN-SITU STRESS
Mark D. Zoback (Department of Geophysics, Stanford University, Stanford, California, 94305), D. Moos, L. Mastin, R.N. Anderson

The detailed cross-sectional shape of stress induced wellbore breakouts has been studied using specially-processed ultrasonic borehole televiewer data. We show breakout shapes for a variety of rock types and introduce a simple elastic failure model which explains many features of the observations. Both the observations and calculations indicate that the breakouts define relatively broad and flat curvilinear surfaces which enlarge the borehole in the direction of minimum horizontal compression. This work supports the hypothesis that breakouts result from shear failure of the rock where the compressive stress concentration around the wellbore is greatest, and that breakouts can be used to determine the orientation of the horizontal principal stresses in-situ.

J. Geophys. Res., B, Paper 4B1300.

6110 Elasticity, fracture, and flow
COMPRESSION-INDUCED MICRO-CRACK GROWTH IN BRITTLE SOLIDS: AXIAL SPLITTING AND SHEAR FAILURE
H. Horii and S. Nemat-Nasser (Department of Civil Engineering, Northwestern University, Evanston, IL 60201)

Micro-mechanisms of rock failure — axial splitting and shear failure — are examined in light of simple mathematical models motivated by microscopic observations. The elasticity boundary-value problem associated with cracks growing from the tips of a model flaw is solved. It is shown that under axial compression, tension cracks nucleate at the tips of the pre-existing model flaw, grow with increasing compression, and become parallel to the direction of the maximum farfield compression. When a lateral compression also exists, the crack growth is stable and stops at some finite crack length. With a small lateral tension, on the other hand, the crack growth becomes unstable after a certain crack length is attained. This is considered to be the fundamental mechanism of axial splitting observed in uniaxially compressed rock specimens. To model the mechanism of shear failure, a row of suitably oriented model flaws is considered and the elasticity boundary-value problem associated with the out-of-plane crack growth from the tips of the flaws is solved. It is shown that for a certain overall orientation of the flaws, the growth of the out-of-plane cracks may become unstable, leading to possible macroscopic faulting. On the basis of this model, the variations of the "ultimate strength" and the orientation of the overall fault plane with confining pressure are estimated, and the results are compared with published experimental data. In addition, the results of a set of model experiments on plates of Columbia resin CR39 containing preexisting flaws, are reported. These experiments are specifically designed in order to show the effect of confining pressure on the crack growth regime. The experiments seem to support qualitatively the analytical results. (Splitting, faulting, crack interaction).

J. Geophys. Res., B, Paper 4B5089

6120 Equations of State
FIRST-PRINCIPLES VS. SPHERICAL ION MODELS OF THE B1 AND B2 PHASES OF NaCl
M. S. T. Bukowinski (Geology and Geophysics Department, University of California, Berkeley, California, 94720), J. Aidun (same as above)

The electron density-functional formalism is used to compute first-principles equations of state and charge distributions for the B1 and B2 phases of NaCl. The B1 equation of state is in excellent agreement with available static, acoustic and shock wave data. The theoretical B2 equation of state differs significantly from available diamond-anvil data but agrees well with shock-wave data. Analysis of the theoretical and experimental isotherms suggest that the former may be a little low in pressure and that the latter is almost certainly too stiff. The computer charge distribution and valence band energies indicate that Cl-Cl interaction may dominate the energetics of the B2 phase and that, consequently, the Cl ions are significantly distorted. The theoretical zero pressure Cl radius is smaller than the classical crystallographical radius, is sensitive to coordination, and expands significantly across the B1 and B2 transformation. In contrast, the Na ion is insensitive to coordination and seems to retain classical ionic properties (+1 charge, spherical charge distribution) up to the highest pressures investigated (70GPa). These properties are largely responsible for the failure of Born-Mayer-type structure independent pair-potentials to accurately account for the changes in elastic properties of NaCl across the B1 - B2 transformation.

J. Geophys. Res., B, Paper 4B1301

6199 General (Permeability)
PERMEABILITY OF UNCONSOLIDATED SANDS AND POROUS ROCKS
A. F. Gangi (Department of Geophysics, Texas A&M University, College Station, Texas, 77843)

Krumbein and Monk found an empirical relationship for the permeability of unconsolidated sand as a function of the mean grain diameter (by weight), d_w, and the standard deviation, σ_ϕ (ϕ=-log$_2$d for d in mm). Their expression, for log-normal grain-size distributions, is

$$k = 760\, d_w^2 \exp(-1.31\sigma_\phi)$$

for d_w in mm, σ_ϕ in ϕ-units and k in darcys. Their data have been reanalyzed to express the permeability in terms of the mean grain diameter by number, d_N. This representation is a more physical one because the permeability depends upon the number of pores of particular sizes (i.e., upon the number distribution function of pore sizes). It is expected that the pore-size distribution function (by number) is more closely related to the grain-size distribution function by number than to the grain-size distribution function by weight. It was found that equally good fits of all their data are given by

$$k = 665\, d_N^2 \exp(1.78\sigma_\phi^3)$$

and

$$k = 648\, d_N^2 (1 + 2.77\sigma_\phi^3).$$

It was found that the expression $k=7354 d_N^2$ gives permeability values that are accurate to 10% for loose, unconsolidated sands (porosity 40±5%) with standard deviation, σ_ϕ, in the range of 0 to 0.5. These results may be applied to porous rocks if Berg's semi-theoretical/empirical determination of the permeability variation with porosity is used (for porosities in the range of 30% to 45%). An expression for the theoretical variation of permeability with effective confining pressure is also given. (Permeability, inconsolidated sands, porous rocks).

J. Geophys. Res., B, Paper 4B1421

Planetology

6510 Atmospheres of Planets
MARTIAN ATMOSPHERIC PHOTOCHEMISTRY AND COMPOSITION DURING PERIODS OF LOW OBLIQUITY
B.L. Lindner (Laboratory for Atmospheric and Space Physics, University of Colorado, Boulder, Colorado, 80309) and B.M. Jakosky

During periods of low obliquity, previous work has shown that Martian CO_2 partial pressures decreased to 0.02 mb 0.1 mb CO_2 partial pressures decreased to 0.02 mb prior to the formation of the Tharsis bulge. The permanent polar caps act as a cold trap and projected global average water vapor abundances drop to possibly as low as 10^{-5} pr µm. As a result, the odd hydrogen catalytic cycle would not be effective at recombining CO and O back into CO_2, and as much as 0.2 mb of CO and 0.1 mb of O_2 could exist. These increased abundances would radically affect surface oxidation, change the lower atmospheric thermal structure, and completely alter the upper atmosphere. (Martian atmosphere, Martian climatology).

J. Geophys. Res., A, Paper 4A8289

6510 Hydrogen, Exosphere, Jupiter
AN EXPLANATION FOR THE H Lya LONGITUDINAL ASYMMETRY IN THE EQUATORIAL SPECTRUM OF JUPITER: AN OUTCROP OF PARADOXICAL ENERGY DEPOSITION IN THE EXOSPHERE
D. E. Shemansky (Center for Space Sciences, Univ. of So. Calif., 3625 E. Ajo Way, Tucson, Arizona 85713)

An analysis of the Voyager EUV spectra of the Jupiter sunlit equatorial emissions shows no evidence for a substantial dependence of atomic hydrogen abundance on magnetic longitude, required by earlier theories of the H Lya longitudinal asymmetry. An explanation for the H Lya bulge phenomenon is advanced in this work that conforms to the observations and does not require a strong asymmetry in atomic hydrogen abundance. It is proposed that the H Lya bulge is caused by a combination of proton collisional transfer of H(ls) atoms into the H(2p) state, and production through recombination of H$^+$ and H$_2^+$, in an asymmetric ionosphere. The asymmetry in the ionosphere is presumably caused by Jupiter's magnetic anomaly. The processes producing the H Lya bulge require a negligible amount of directly applied energy. However the process is a symptom of the process of substantial deposition of energy in the exosphere, forming the major source for ionospheric particles and contributing substantially to the upper atmospheric temperature. According to the present model a large fraction of the observed H Lya emission from the equatorial region is electron excited, at least at times of solar maximum. Other related phenomena and quantities required to maintain the H Lya asymmetry are discussed in the text.
5505

J. Geophys. Res., A, Paper 4A8207

6520 Comets
AN IMPROVED THERMAL MODEL FOR COMETARY NUCLEI
P. R. Weissman (Earth and Space Sciences Division, Jet Propulsion Laboratory, Pasadena, CA 91109), H. H. Kieffer

We have modified our earlier thermal model of cometary nuclei by incorporating a more accurate calculation of the opacity of the cometary dust coma. The new model uses a modified Sekanina-Miller dust particle size distribution and a Delsemme-Miller gas outflow dynamics model. The improved model has been applied to the case of the 1986 apparition of Halley's Comet, also incorporating a revised radius and albedo for the Halley nucleus. The estimated opacity of the Halley coma is reduced from that of the earlier model. The revised opacity is 0.12 at 1.0 AU and 0.43 at perihelion, 0.587 AU. This results in a decrease in the energy supplied to the nucleus from the coma by multiply scattered radiation and thermal emission, and brings the model into better agreement with the results of others. The coma feedback mechanism enhances nucleus gas production by a factor of 1.4 at 1.0 AU over that for a bare ice nucleus with no dust coma, and by a factor of 2.1 at perihelion. Predicted gas production at 0.9 AU post-perihelion, the expected heliocentric encounter distance for the Giotto mission, is 4.4 x 10^{29} molecules per second. This agrees well with a recent estimate of 3.9 x 10^{29} molecules s^{-1} for the Halley gas production rate at 0.9 AU during the 1910 apparition.

J. Geophys. Res., B, Paper 4B5924

6525 Gross properties of the moon
MAGNETIC FIELD AMPLIFICATION AND GENERATION IN HYPERVELOCITY METEOROID IMPACTS WITH APPLICATION TO LUNAR PALEOMAGNETISM
L. L. Hood (Lunar and Planetary Laboratory, University of Arizona, Tucson, Arizona, 85721) and A. Vickery

A continuing difficulty for the core dynamo hypothesis for the origin of lunar paleomagnetic fields is the small maximum size of a present-day iron core and correspondingly small estimates for maximum lunar surface paleofields based on available models for planetary magnetic field generation. This paper explores the possibility that magnetic fields may be significantly amplified or generated in large-scale meteoroid impacts and that these fields may have contributed substantially to the observed magnetization of lunar materials. Using a one-dimensional numerical model for expansion of impact-produced vapor clouds, scalar electrical conductivities for the expanding partially ionized gas are calculated to be in the range $10^0 - 10^6$ s m^{-1} for meteoroids with representative compositions impacting at velocities greater than the threshold for significant vaporization (~10 km s^{-1}). Magnetic diffusion will therefore be small in comparison to advection on relevant time scales. The available gas kinetic and internal energy densities are $\ge$ probable magnetic energy densities for time periods that increase with increasing impactor velocity and size. These periods represent limits on the time available for magnetic field amplification/generation and are in the approximate range $10^{-2} - 10^2$ s for meteoroids with radii between 1 and 200 km impacting at 15 km s^{-1}. Pre-existing solar wind magnetic fields will be compressed by the expanding plasma cloud and amplified by induction in the presence of an electrically conducting lunar interior. Within the limitations of the one-dimensional modeling results, maximum surface field amplitudes expected via these mechanisms are ~ 0.01 G so that their importance with respect to lunar paleointensities (0.01 - 1.0 G) is marginal. However, existence of a core dynamo during the 3 - 4 b.y. time period with surface fields of ~ 0.003 G would increase maximum induced field amplitudes to values compatible with the range of lunar paleointensities. Direct generation of transient fields in impact-produced plasmas via currents forced by thermal pressure gradients will occur but estimated field amplitudes for large-scale impacts ($10^{-4} - 10^{-3}$ G) are too small to contribute to lunar paleointensities. Dynamo amplification of these fields as a result of expansion velocity gradients and turbulence within the expanding plasma cloud is possible within available time periods but necessary conditions for achieving lunar paleointensity amplitudes have not been demonstrated.

J. Geophys. Res., B, Paper 4B5917

6570 Lunar Soils
CHEMISTRY AND PETROLOGY OF APOLLO 12 DRIVE TUBE 12027
M. R. Smith (Radiological Sciences Department, Battelle Pacific Northwest Laboratories, Richland, Washington, 99352), J. C. Laul, S. B. Simon and J. J. Papike

Modal and chemical data for 31 major, minor, and trace elements obtained by INAA for soils from four (~5 cm) depth intervals of drive tube 12027 show three compositional units within the core. The upper ~2.5 cm of 12027 represents part of the Sharp Crater rim crest deposit, which has a total thickness of ~23 cm. Chemical differences are attributed to addition of local mare rocks to the upper 2 cm and KREEPy material to the lower stratigraphic layer (14-17 cm depth). The coarser fractions (1000-90, 90-20, and 20-10 µm) are compositionally similar to each other but quite different from the <10 µm fine fractions, which are more feldspathic and enriched in incompatible (LIL) elements. Correlation between fused soil contents and LIL enrichments of the coarse fractions strongly suggests that agglutinates are derived from the fine fraction, thus supporting the F^3 (Fusion of the Finest Fraction) model. The trench soil 12033, from ~15 cm depth, is very similar to the 15.5 - 16 cm soil of core 12027, indicating that the Apollo 12 regolith exhibits KREEP enrichments at various depths and that exotic KREEPy ejecta are widespread at the Apollo 12 site. (Lunar soils, Apollo 12, core studies, regolith).

J. Geophys. Res., B, Paper 4B5808.

6599 General (Review)
LIGHTNING ON OTHER PLANETS
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The possibility of the existence of extraterrestrial lightning is considered from the present knowledge on the atmospheres of the planets including the satellites Io and Titan. Optical and r.f. wave measurements from spacecraft have yielded evidence of electrical activity on Venus, Jupiter and Saturn. The conclusion that those emissions are definitely from lightning is not unambiguous because of poor data bases. The observations attributed to lightning are reviewed and discussed. (Lightning, planetary atmospheres).

J. Geophys. Res., D, Paper 4D1425

Seismology

6920 Explosion Seismology
SPALL OBSERVATIONS AND MECHANISMS IN ALLUVIUM
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Spall, as identified by almost 1 g dwells on vertical accelerograms followed by impulsive rejoin signals, has been observed in ground motion data recorded in alluvium. These data resulted from explosions ranging from fully contained to surface burst configurations. The variability of the loading environments and the observational data support the conclusion that the phenomena result from multiple mechanisms. The data show that relatively low accelerations (<10 g's) accompany the process, but, due to the long dwell times involved, resulting displacements may be large. Five spall models are discussed and shown to operate in some aspect of the data base. These mechanisms include: (1) simple tensile reflection from the free surface, (2) Rayleigh/shear waves from surface sources, (3) spherical and cylindrical wave field divergence, (4) positive and negative phase airblast effects on porous materials, and (5) material properties of porous particulate matter.

J. Geophys. Res., B, Paper 4B1069.

6940 Seismology
SEISMIC POTENTIAL FOR LARGE AND GREAT INTERPLATE EARTHQUAKES ALONG THE CHILEAN AND SOUTHERN PERUVIAN MARGINS OF SOUTH AMERICA: A QUANTITATIVE REAPPRAISAL
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The seismic potential of the Chilean and southern Peruvian margins of South America is reevaluated to delineate those areas or segments of the margin that may be expected to experience large or great interplate earthquakes within the next 20 years (1984-2004). Long-term estimates of seismic potential (or the conditional probability of recurrence within a specified period of time) are based on (1) statistical analysis of historic repeat time data using Weibull distributions and (2) deterministic estimates of recurrence times based on the time-predictable model of earthquake recurrence. Both methods emphasize the periodic nature of large and great earthquake recurrence, and are compared with estimates of probability based on the assumption of Poisson-type behavior. The estimates of seismic potential presented in this study are long-term forecasts only, as the temporal resolution (or standard deviation) of both methods is taken to range from ±15% to ±25% of the average or estimated repeat time. At present, the Valparaiso region of central Chile (32°-35°S) has a high potential or probability of recurrence in the next 20 years. Coseismic uplift data associated with previous shocks in 1822 and 1906 suggest that this area may have already started to rerupture in 1971-1973. Average repeat times also suggest this area is due for a great shock within the next 20 years. Flanking segments of the Chilean margin, Coquimbo-Illapel (30°-32°S) and Talca-Concepcion (35°-38°S), presently have poorly constrained but possibly quite high potentials for a series of large or great shocks within the next 20 years. In contrast, the rupture zone of the great 1960 earthquake (37°-46°S) has the lowest potential along the margin and is not expected to rerupture in a great earthquake within the next 100 years. In the north, the seismic potentials of the Mollendo-Arica (17°-18°S) and Arica-Antofagasta (18°-24°S) segments (which last ruptured during great earthquakes in 1868 and 1877) are also high, but poorly constrained. (Earthquake forecasting, Chile, Peru).

J. Geophys. Res., B, Paper 4B0511

6950 Seismic sources
A RE-EXAMINATION OF THE MOMENT TENSOR SOLUTIONS OF THE 1980 MAMMOTH LAKES EARTHQUAKES
T. C. Wallace (Geosciences Department, University of Arizona, Tucson, Arizona, 85721)

The moment tensor solutions determined from both long period body and surface waves for most of the large earthquakes in the 1980 Mammoth Lakes sequence have substantial deviations from a pure double couple mechanism. Julian (1983) and Aki (1984) argue that these deviations require non-shear faulting seismic sources such as a CLVD which could represent magmatic dike injection. Here we re-examine the moment tensor solutions and investigate the effects of the non-double couple source on body wave synthetics. An error function which is based on the cross-correlation of a synthetic and an observed waveform was used to assess the difference in fit between the complete moment tensor solution and one constrained to be a double couple. For the mainshock (May 25, 1980) 1633, the sum of the errors differed by less than 5% for the two models. Similarly, the errors differed by only 3% for the aftershock on May 27, 1980. The conclusion is that the CLVD mechanism is not resolved in the long-period data. In addition, the complete moment tensor solution has an extra parameter; a test was applied to normalize the number of parameters, and it was found that the complete solution was slightly less significant than the double couple solution. Finally, the complete solution was compared to a pure CLVD solution, for all the events examined the total moment tensor is as far removed from a CLVD as it is a double couple. Although this does not rule out the possibility of dike injection, it strongly suggests that faulting can account for the long-period seismic observations in the 1980 swarm. (CLVD, moment tensors).

J. Geophys. Res., B, Paper 4B1335

6950 Seismic sources
A RENORMALIZATION GROUP APPROACH TO THE STICK-SLIP BEHAVIOR OF FAULTS
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Sara A. Solla (Laboratory of Atomic and Solid State Physics, Cornell University, Ithaca, New York, 14853)

We treat a fault as an array of asperities with a prescribed statistical distribution of strengths. When an asperity fails the stress on the failed asperity is transferred to one or more adjacent asperities. For a linear array the stress is transferred to a single adjacent asperity and for a two-dimensional array to three adjacent asperities. Using a renormalization group (RG) method we investigate the properties of a scale invariant hierarchical model for the stochastic growth of fault breaks through induced failure by stress transfer. An extrapolation to arbitrarily large scales shows the existence of a critical applied stress at which the solutions bifurcate. At stresses less than the critical stress virtually no asperities fail on a large scale and the fault is locked. Above the critical stress asperity failure cascades away from the nucleus of failure. We interpret this catastrophic failure as an earthquake and it corresponds to the transition from stick to slip behavior on the fault. Thus the stick-slip behavior of most faults can be attributed to the distribution of asperities on the fault. We propose our stochastic mechanism as an alternative to the traditional hypotheses for the stick-slip behavior of faults. A major advantage of our approach is the inclusion of scale invariance. Thus the observed frequency-magnitude relation for seismicity is a natural consequence of our basic hypothesis.

J. Geophys. Res., B, Paper 4B1324.

Social Sciences

7310 Economics
COST-SHARING FOR FEDERAL WATER PROJECTS: TRENDS AND IMPLICATIONS
John J. Waelti (Department of Agricultural and Applied Economics, 282C COB, University of Minnesota, St. Paul, Minnesota, 55108)

The major water policy events beginning with the 1950's are reviewed with respect to their bearing on proposed changes in the much criticized Federal policies for non-Federal cost sharing. The cost-sharing proposals of the Carter and Reagan Administrations are reviewed. These proposals are discussed with respect to theoretical economic efficiency and political equity. Both sets of proposals represented improvements over the traditional system. However, both were defeated because of political opposition. (Cost sharing, water policy).

Water Resour. Res., Paper 4W1264.

Solar Physics, Astrophysics, and Astronomy

7760 Radio Astronomy
RADIO EMISSIONS FROM THE PLANETS EARTH, JUPITER, AND SATURN
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We review the major observed and inferred features of the three currently known nonthermal radio planets, the earth, Jupiter and Saturn. Several of the properties of the three planets are quite similar, suggesting that the same processes take place at all three. In addition, Jupiter has two radio components in the low-frequency range which may not have analogs at the earth or Saturn. We speculate on the expected addition of Uranus to this list of radio planets.

Rev. Geophys. Space Phys., Paper 4R1298

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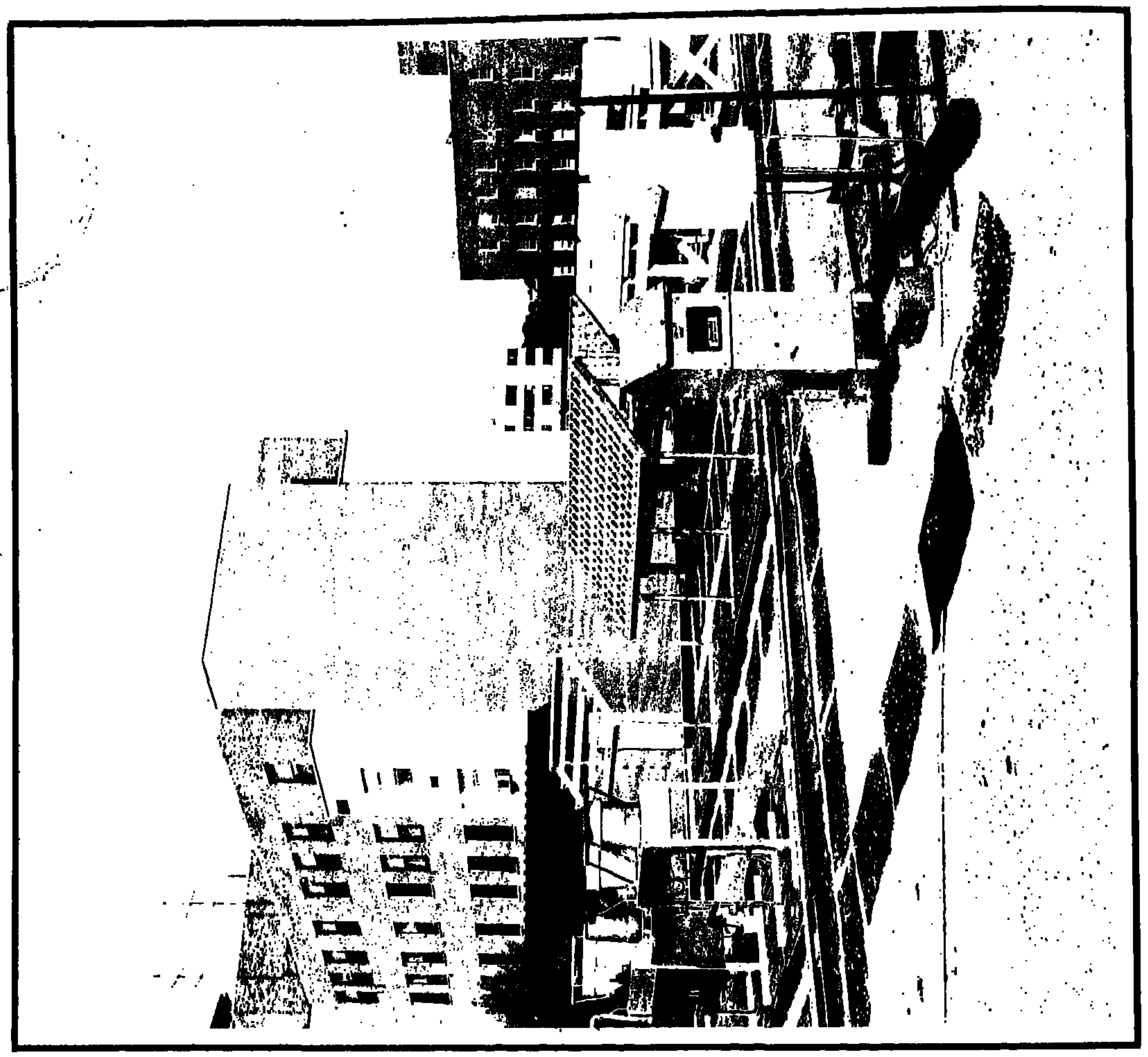

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Tectonophysics

8110 Convection Currents
AN EXPERIMENTAL APPROACH TO THERMAL CONVECTION IN A TWO-LAYERED MANTLE
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If the 650 km discontinuity marks a compositional boundary, as has been suggested, then the upper and lower mantle may be convecting separately. A series of laboratory experiments on two-layered convection were made in order to determine how thermal convection interacts with a stable density discontinuity. The working fluid consisted of two superposed layers of GLOBE 1132 syrup, a glucose solution with a Newtonian viscosity which depends strongly on temperature. The initial density contrast between layers ranged from 0.5% to 8%. A uniform heat flux was supplied to the base of the lower layer. By varying the heat flux, Rayleigh numbers between 4×10^4 and 1×10^7 were obtained. In every case, two-layered convection was observed, but in no case did a steady state result. Instead, a slow mixing between the layers occurred, driven by viscous stresses acting on the density interface. The mixing mechanism was provided by convective eddies which entrained fluid across the discontinuity in the form of thin schlieren. Mixing continued until the density contrast across the discontinuity became small enough to permit overturning. The mixing rate was determined by monitoring changes in dye concentration in each layer. It is found that the mixing rate is governed by the bulk Richardson number Ri, a measure of the ratio of between interfacial buoyancy and viscous forces. Mixing rate data from experiments covering the range $80 < Ri < 3300$ are consistent with a power law of the form

$$\frac{1}{\Delta\rho}\frac{d}{dt}\Delta\rho = -0.05\,\dot{\varepsilon}\,Ri^{-1}$$

where $\Delta\rho$ is the density jump across the discontinuity and $\dot{\varepsilon} = (q/\rho H_T)^{1/2}$ is the scale for convective strain rate. Applying this mixing law to the mantle indicates that mass exchange between the upper and lower mantle could occur by this mechanism at a rate of $10^{18} - 10^{19}$ kg. per million years. Convectively driven entrainment across the 650 km density discontinuity can provide a mechanism for interaction between the upper and lower mantle and may be an important source of mantle heterogeneity.

J. Geophys. Res., B, Paper 4B1056

8170 Structure of the Lithosphere
STRUCTURAL DISCORDANCE BETWEEN NEOGENE DETACHMENTS AND FRONTAL SEVIER THRUSTS, CENTRAL MORMON MOUNTAINS, SOUTHERN NEVADA
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Detailed geologic mapping in the Mormon Mountains of southern Nevada provides significant insight into processes of extensional tectonics developed within older compressional orogens. A newly discovered, WSW-directed low-angle normal fault, the Mormon Peak detachment, juxtaposes the highest levels of the frontal-most part of the east-vergent, Mesozoic Sevier thrust belt with autochthonous crystalline basement. Palinspastic analysis suggests that the detachment initially dipped 20-25° to the west and cut discordantly across thrust faults. Nearly complete lateral removal of the hanging wall from the area has exposed a 5 km thick longitudinal cross-section through the thrust belt in the footwall, while highly attenuated remnants of the hanging wall (nowhere more than a few hundred meters thick) structurally veneer the range. The present arched configuration of the detachment resulted in part from progressive "domino-style" rotation of a few degrees while it was active, but is largely due to rotation on younger, structurally lower, basement-penetrating normal faults that initiated at high-angle.

The geometry and kinematics of normal faulting in the Mormon Mountains suggest that pre-existing thrust planes are not required for the initiation of low-angle normal faults, and even where closely overlapped by extensional tectonism, need not function as a primary control of detachment geometry. Caution must thus be exercised in interpreting low-angle normal faults of uncertain tectonic heritage such as those seen in the COCORP west-central Utah and BIRP's MOIST deep-reflection profiles. Although thrust fault reactivation has reasonably been shown to be the origin of a very few low-angle normal faults, our results indicate that it may not be an fundamental a component of orogenic architecture as it is now widely perceived to be. We conclude that while in many instances thrust fault reactivation may be both a plausible and attractive hypothesis, it may never be assumed.

Tectonics, Paper 4T0792

8170 Structure of the Lithosphere
THE SNAKE RANGE DECOLLEMENT INTERPRETED AS A MAJOR EXTENSIONAL SHEAR ZONE
J. M. Bartley (Department of Geology, University of North Carolina, Chapel Hill, North Carolina, 27514) and B. P. Wernicke

Geological and geophysical constraints suggest that the Snake Range décollement of east-central Nevada is a major Tertiary low-angle normal fault zone. This interpretation is consistent with all existing data, and alleviates problems that result if large displacement across the décollement is excluded [Miller et al., Tectonics, 2, 239-263, 1983]. We have constructed cross sections that suggest approximately 60 km of normal displacement on the décollement. Advantages of this interpretation over models that exclude large displacement are that it: (1) provides for overburden consistent with kyanite-grade metamorphism of footwall rocks, (2) predicts reasonable crustal thicknesses before and after extension without invoking unexposed mantle-derived Tertiary intrusions at depth, and (3) explains contrasting metamorphism and structural styles of hanging wall and footwall without requiring an extreme geothermal gradient during regional metamorphism and extensional strain. (extensional tectonics, Great Basin, low-angle normal fault).

Tectonics, Paper 4T0937

8199 General (Colorado Plateau Boundary)
A MODEL FOR THE TECTONIC DEVELOPMENT OF THE SOUTHEASTERN COLORADO PLATEAU BOUNDARY
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Stress data show that the contemporary tectonic boundary of the southeastern Colorado Plateau is coincident with the segment of the Jemez lineament between the White Mountains in east-central Arizona and the Jemez Mountains in north-central New Mexico. The lineament is actually a broad (~50 km wide) tectonically active zone that trends N.52°E. and approximately coincides with a Precambrian province boundary. It is characterized by extensive late Tertiary-Quaternary volcanic fields, NNE-trending (~N.25°E.) en echelon faults, and both normal and strike-slip faulting. Pliocene-Quaternary normal oblique-slip displacements have been observed on faults within and south of the lineament but not north of it. Late Laramide NE-SW compression, which caused widespread tectonic shortening throughout the western Cordillera, apparently was transformed into left-slip along the Jemez lineament. As the Precambrian basement underwent strike-slip faulting, a belt of NNE-trending en echelon faults developed in the overlying Phanerozoic sedimentary strata. By the end of the Laramide orogeny 40 Ma ago the principal structural elements of the lineament, seen today, had been formed. Volcanism in the Datil-Mogollon volcanic field began after the cessation of Laramide tectonism, and heated the crust around the southeastern edge of the Colorado Plateau. These elevated temperatures further weakened the part of the physiographic Plateau immediately south of the Jemez lineament so that with the onset of SW-NE extension in the southern Basin and Range Province, about 30 Ma ago, this area deformed more in response to the extension than to the stress field of the Plateau interior. The emplacement of large NW-trending dikes into the area between 27 and 29 Ma ago was directly related to this extensional event. During the late Miocene the direction of spreading changed to a W and WNW orientation allowing the Colorado Plateau to begin a small clockwise rotation. Coeval left-slip and extension occurred across the Jemez lineament. Major volcanism on the lineament was initiated by the change in spreading direction. Volcanic activity started at the weakest points first, where the lineament is intersected by the Rio Grande Rift (Jemez Mountains) and Capitan lineament (White Mountains). With increasing extension across the lineament between 7 to 4 Ma ago the NNE-trending faults opened, and by the earliest Pliocene (~4-5 Ma ago) volcanism was occurring along the entire southeastern tectonic boundary (Jemez lineament) of the Colorado Plateau.

J. Geophys. Res., B, Paper 4B0951

8199 General Tectonophysics
THE YAQUI RIDGE ANTIFORM AND DETACHMENT FAULT: MID-CENOZOIC EXTENSIONAL TERRANE WEST OF THE SAN ANDREAS FAULT
P. A. Schultejann (Scripps Institution of Oceanography, University of California, San Diego, La Jolla, CA 92093)

The Yaqui Ridge antiform and detachment fault in southern Borrego Valley, California, exemplifies the nature of detached terranes in south central California. The detachment fault dips 10°-40° to the north and northeast, and separates a lower core of gneissic Late Cretaceous granodiorite from an unconsolidated, unmetamorphosed megabreccia of probable Eocene to Late Oligocene age. Foliations in the lower plate generally conform to the strike and dip of the overlying detachment fault, and become less distinct away from the fault. The megabreccia which forms the upper plate is composed of unsorted, fairly well-rounded clasts characteristic of batholithic and metasedimentary rocks of the region. Plio-Pleistocene lacustrine sediments unconformably overlie the megabreccia in some areas. The detachment fault itself forms a thin veneer over a ~10 cm band of intensely sheared cataclasite. A chlorite-breccia zone occurs below the cataclasite and gradually grades into the gneissic granodiorite. A left-oblique-slip shear zone cuts through the detachment-related features and strikes WNW-ESE, parallel to Yaqui Ridge antiform. Four tectonic episodes are apparent at Yaqui Ridge: (1) Late Cretaceous synkinematic mylonitization and metamorphism, forming a regional NW-striking foliation and NE-trending mineral lineation; (2) mid-Cenozoic shallow, low temperature detachment faulting; (3) Late Miocene-Early Pliocene, left-oblique slip faulting; (4) Pleistocene high-angle faulting and folding. (Detachment faults, low-temperature, south central California).

Tectonics, Paper 4T0791

8199 General (Tectophysics)
LATE MESOZOIC AND CENOZOIC TECTONIC HISTORY OF SOUTH CENTRAL CALIFORNIA
A. E. J. Engel (Scripps Institution of Oceanography, La Jolla, California 92093), and P. A. Schultejann

The late Mesozoic-Cenozoic history of south central California is punctuated by at least five major tectonic events. The oldest of these involves Late Cretaceous folding and thrusting of epiconal shelf sediments westward over and to the north along the rising eastern margin of the Peninsular Ranges Batholith. A second, distinct episode is superimposed upon the Late Cretaceous structural features, and involves low T and P, mid-Tertiary detachment faulting. This represents the westerly extension of the detachment terrane of eastern California and western Arizona. The Late Cretaceous and detachment features are further disrupted by both left-lateral and right-lateral faulting during the late Cenozoic. This faulting is accompanied by oblique-slip faulting, dip-slip faulting, and folding which continues into Holocene time. Many of the most recent structural features indicate N-S compressional strain in south central California. (thrusting, detachment faults).

Tectonics, Paper 4T0790